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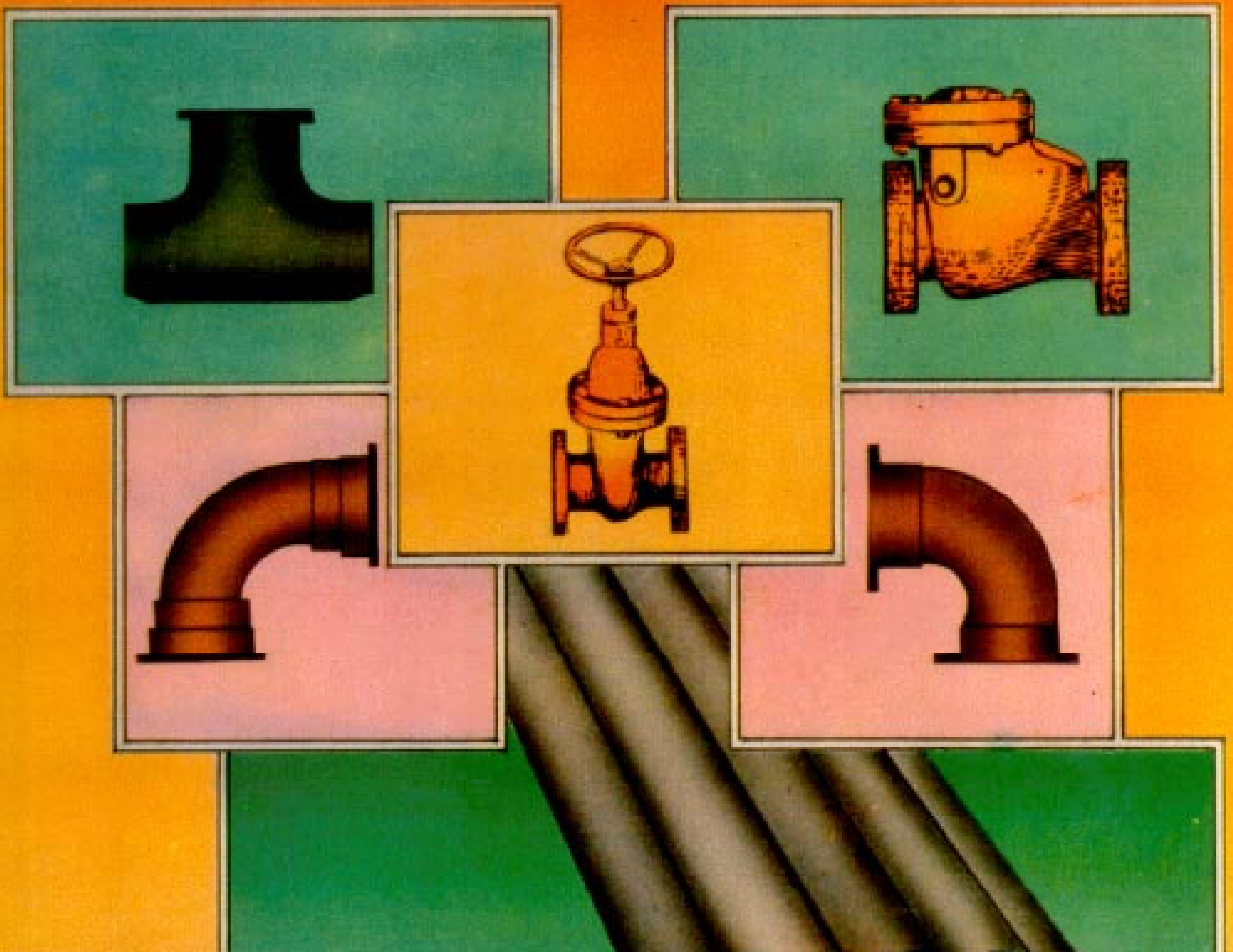
Handbook On Pipes And Fittings For Drinking Water Supply



Bureau of Indian Standards

HANDBOOK

ON

PIPES AND FITTINGS FOR DRINKING WATER SUPPLY

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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FOREWORD

The standards and code of practices for various materials and equipment used in the rural drinking water supply are brought out by the Bureau of Indian Standards regularly. The use and application of the same in the implementation of the programme is important to ensure the safe supply of water to the rural population.

Pipes and fittings represent a major investment in the water supply project. The judicious selection of the same keeping in view the different aspects like durability, life, cost, installation and ease of maintenance would be an important decision making in the successful implementation and running of the system during its designed life period.

At the request of the Rajiv Gandhi National Drinking Water Mission, Bureau of Indian Standards has brought out a handbook by carefully pooling together all the relevant standards and specifications already published by them, making the job of professionals easy to guide in selecting the right type of pipe material to suit the field conditons and also for proper handling, laying, jointing and testing of the completed pipelines. This handbook should, therefore, be an effective tool in the hands of the field engineers to arrive at decision while designing water supply projects.

(NIRMALA BUCH)

Lt Gen A. S. Bhullar, PVSM, AVSM (Retd)
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PREFACE

The Bureau has been associated with the Rajiv Gandhi National Drinking Water Mission and has lent its full support in this project.

The Bureau's contribution focusses on quality in the material/products used, construction/installation, operation and maintenance of the works. To meet the above objectives BIS prepares National Standards by pooling the experience of relevant experts in order to ensure uniformity, save time and resources at least in repetitive items. It also conducts training programmes on :

i) Statistical Quality Control to the BIS licensed manufacturers, and

ii) Sampling and testing of products/materials to organized purchasers.

It conducts periodically awareness programmes for water supply engineers throughout the country for effective interaction to get feed back.

Further BIS provides third party certification for products, which helps the users in choosing products conforming to standards thereby avoiding further inspection and testing.

A strong need has been felt during the interactions for concise handbooks on some subjects on the basis of Indian Standards and providing additional material to cover the subject fully.

This handbook on Pipes and Fittings for Drinking Water Supply is based on material collected and collated from more than 200 Indian Standards; a list of the relevant main standards is given in the Annex to the Handbook.

Other handbooks in the series, which will be issued shortly, cover tubewells/bore wells and pumps used in water supply.

Use of this handbook and the referred standards besides the relevant ISI marked products, would go a long way in enhancing the quality of pipe installations for water supply. The resulting feed back to BIS would ensure improvement of the related standards and the Handbook.

Lt Gen A.S. Bhullar

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0 INTRODUCTION

Pipes have been used for many centuries for transporting fluids especially drinking water. The Chinese first used bamboo pipes thousands of years ago and lead pipes were unearthed at Pompeii. In later centuries wood stave pipes were used in England. It was only with the advent of cast iron that pressure pipes were manufactured. Cast iron was extensively used in 19th Century and is still used. Steel pipes were first introduced towards the end of the last century, facilitating small and large bore pipe-lines. The increasing use of high grade steels and large rolling mills has enabled production of pipe-lines with larger diameters and higher working pressures. Pipe-lines are also made in reinforced cement concrete, prestressed concrete, asbestos cement, plastics and clayware, to suit varying conditions. Reliable flow formulae became available for the design of pipe-lines during this century, thereby promoting economical use of pipes.

Protected water supply in rural areas is essential in improving the environment and health of the community, and piped water supply is one of the methods adopted for protected water supply, when the source of water is located at a distance from the area of consumption.

The selection of appropriate type of pipe material for vastly varied rural community set up in India will involve many factors and no single solution can be found. The varied factors include different patterns of settlement and areas of rural community, economic level, availability of finance, quantum of potable water, skill and experience of local people in installation, operation and maintenance of the system, etc. The optimum and practical solution should take the above factors into account and wherever possible the standardized design for similar set up should be used. The areas with special features shall be studied in detail and the relevant features considered for selection of the right type of pipe material.

Pipe-lines are major investments in water supply projects and as such constitute a major part of the assets of water authorities. Therefore, pipe material shall be judiciously selected from the point of view of durability, life and overall cost which includes besides the pipe cost, the installation and maintenance cost necessary to ensure the required function and performance of the pipe-line throughout the designed life time.

Bureau of Indian Standards has published a number of Indian Standards for various types of pipes and fittings and codes of practice for laying and jointing of pipes. This hand book has been prepared mostly based on them with an intention to guide the field engineer in selecting the right type of pipe material to suit the field conditions and requirements of the project and to give a guidance in proper handling, laying and jointing and testing of completed pipe-line.

Although an attempt has been made to summarize the requirements given in the relevant Indian Standards in this hand book, a reference may invariably be made to those Indian standards, a list of which is given in Annex A for exhaustive study. Further, the terminology used in this hand book is as given in IS 2065 : 1983 and IS 10446 : 1983.

CHAPTER 1 GENERAL CRITERIA FOR SELECTION OF PIPES

1 FACTORS TO BE CONSIDERED IN SELECTION

The following factors shall be taken into account in the selection of pipes.

1.1 The Strength of the Pipe

This is the ability of the pipe to withstand internal pressure and external loads.

Pipe-lines are expected to resist a number of forces individually or in combination as mentioned below :

a) Internal water pressure equal to full head of water;

b) Surge pressure or water hammer due to sudden opening and closing of valves, and in pipes connected to pumps;

c) External loads in the form of back-fill and traffic; and

d) Expansion and contraction of pipes with change in temperature.

Reinforced cement concrete pipes cater to the internal working pressure up to 0.3 MPa (3.0 kgf/cm^2) whereas cast iron and steel pipes cater to internal working pressure up to 2.4 MPa (24 kgf/cm^2). Prestressed concrete pipes and asbestos cement pressure pipe cater to intermediate pressure range for which the metallic pipes are expensive and RCC pipes would not be suitable. Similarly plastic pipes cater to internal working pressures up to 1.0 MPa (10 kgf/cm^2).

Though steel pipes are capable of resisting high internal pressures, the ability of large steel pipes to withstand external loads while empty or in partial vacuum is very poor due to their low thickness. In such cases, pipes must be guarded by limiting the superimposed loads or by surrounding (embedding) pipes in concrete. The cast iron and asbestos cement pressure pipes are good for moderate external loads. RCC pipes can withstand high external loads.

1.2 Water Carrying Capacity

The water carrying capacity of a pipe-line mainly depends on relative roughness of pipe, friction factor, and Reynolds Number of the flow. Rational formulae should preferably be used [*see* IS 2951 (Part 1) : 1965 for details]. However still in practice, empirical formulae are widely used; of these Hazen-Williams formula is most popular. For example in Hazen-William's formula coefficient *'C'* varries for different conduit materials and their relative deterioration in service. It also varies with size and shape and laying of pipes. The loss of capacity during service depends on the quality of water carried and characteristics of the pipe material. The loss of water carrying capacity is relatively more rapid for smaller diameter pipes than the larger diameter pipes. In cast iron and steel pipes, it is due to the interference of rust and deposits due to incrustation of pipes that restrict the water way and increase the roughness of pipe walls. In cement lined pipes and asbestos cement pipes the smooth surface of the walls is destroyed by erosion. The losses in water carrying capacity is more in distribution lines than that in supply lines. It is due to losses in valves, fittings and other appurtenances that are far greater in number in distribution lines. These losses can be reduced to some extent by well designed bends and tees, etc. The values of Hazen-Willams coefficient *'C'* for new conduits and recommended values to be adopted for design purpose, for various pipe materials is given in Table 1.

Table 1 Hazen-Williams Coefficient

(*Clause* 1.2)

Sl No.	Pipe Material	Recommended 'C' Values for New Pipes	
		New Pipes	Design Purpose
	(1)	(2)	(3)
i)	Cast iron	130	100
ii)	Galvanized iron greater than 50 mm dia	120	100
iii)	Galvanized iron 50 mm dia and below for service connection	120	55
iv)	Steel pipes welded-lined with cement or bitumenous enamel	140	110
v)	Concrete	140	110
vi)	Asbestos cement	150	120
vii)	Plastic pipes	150	120

1.3 The Life and Durability of Pipe

It is determined by the resistance of cast iron and steel pipes to corrosion; concrete and asbestos cement pipes to erosion and disintegration, and plastic pipes to cracking, etc.

1.4 Transportation

Most often the pipe-lines are to be constructed in rugged and normally inaccessible locations. In such cases mass of the pipes becomes an important criterion. Cast iron pipes are heavy in bigger sizes. Steel pipes are relatively lighter though bulky because of longer section ordinarily employed. Plastic pipes are much lighter when compared to cast iron or asbestos cement pipes. RCC and asbestos cement pipes are not only heavy but also call for careful handling.

1.5 Safety

Because of suddenness and extensiveness of failure, breaks in cast iron pipes are often quite destructive. Steel pipes fail slowly, mainly due to corrosion, which results in small leaks at scattered points and repairs are simpler. Collapse of steel pipes under vacuum while the line is being drained is possible but is a rare occurence. Asbestos cement pipes fail much like cast-iron pipes. RCC and asbestos cement pipes should not be laid over/in soil containing sulphates.

1.6 Availability of Skilled Labour

Skill is particularly required for making joints in the pipe-line. Welded and poured joints require more skilled labour than mechanical joints.

1.7 Maintenance and Repairs

The requirements of maintenance and repairs, losses of water due to leakage and other characters of pipe behaviour and ability shall be considered in selection of material.

1.8 Cost Effectiveness of Various Pipe Materials

1.8.1 *Factors to be Considered for Cost Effectiveness*

Cost effectiveness of various pipe materials is dependent on many factors and some of them are summarised below for guidance.

- a) *Initial cost* — The initial cost of the pipe-line includes the cost of pipe, fittings, and laying material. This will also include increase in the cost due to breaking of pipes at any stage in laying of pipe-line.
- b) *Storage, handling and transportation cost* — This includes the cost of storage, handling and transportation of pipe-line from the point of purchase to the place where it is to be laid.
- c) *Laying cost* — The labour cost to be incurred in digging of trenches, laying of pipe-line jointing and closing of trenches.
- d) *Life of project* — The life of pipe-line of various materials will vary and no realistic estimate can be made for the same. This will have to be assesed by the project incharge depending upon the conditions prevailing in the area to be covered by the pipe-line.
- e) *Community/individual supply connections* — The cost of pipe-line and choice of pipe material will also depend on whether community water connections or individual water connections are being provided in a particular area.
- f) *Recurring/maintenance cost* — The cost effectiveness as a long term measure should also take care of recurring/maintenance cost likely in the form of replacing defective pipe and labour cost in the same.
- g) *Chances of leakage* — The chances of leakage should be kept in mind while choosing a particular material depending upon availability of water.
- h) *Pilferage factor* — The chances of pilferage of pipe material, must also be kept in mind while deciding about the particular material for the pipes.
- j) *Service conditions* — The weather and surrounding environment which the pipe-line is likely to encounter during its life time should be assessed before finalizing the pipe materials.
- k) *Contamination of water* — The contamination of water due to any reason should be assessed and the more suitable pipe material should be chosen to ensure potable water supply to the consumers.
- m) *Type of soil* — The soil type will have lot of bearing on the pipe material suitable for a particular location. The chances of corrosion of metallic pipes should be assesed in the particular soil before using it.

n) *Loss of head* — The energy loss is experienced in all pipes but it is higher in rougher materials and will also be dependent on the fittings in the layout of a pipe-line. Therefore, suitable pipe material should be chosen for the head available in a particular location.

p) *Crossings* — The crossings like railway, canal, road, etc, should be studied before finalizing the choice of a pipe material in a particular project.

CHAPTER 2 PROPERTIES OF PIPES

1 Material selection is probably one of the methods that could solve most corrosion and erosion problems, but due to economic considerations it is not always used.

Considerable literature is available about the corrosion and erosion aspects of materials. But while selecting pipe material other factors like economics, use of less expensive material, influence of factors like availability of skilled personnel and proper pipe handling techniques also must be considered.

In this chapter, advantages and disadvantages of various pipe materials are discussed, in brief, to guide the user to select the proper material. For the sake of convenience the pipes are classified into 3 groups as given below, keeping in view the material used for manufacture:

a) Metallic pipes,

b) Cement pipes, and

c) Plastic pipes.

2 METALLIC PIPES

Cast iron pipes (both sand cast and spun cast), ductile iron pipes, welded steel pipes and spiral welded steel pipes come in the categery of metallic pipes. Because of ease in production and jointing cast iron (CI) pipes are very extensively used for water supply purpose. In our country CI pipes are in use for more than a century. The development of steel pipes imparted a great significance in pipe laying, because of its light weight when compared to CI pipes. Ductile iron pipes are recent development in metallic pipes, which are basically spun cast iron pipes with improved metallurgical properties. The great advantage of metallic pipes is their high strength and mechanical properties which permits them to carry high internal pressures as well as external loads. Damages to metallic pipes in transport and handling are minimal when compared to other varieties especially cement pipes. Corrosion is the greatest disadvantage in metallic pipes as it not only reduces wall thickness and strength of the pipes but also reduces the flow capacity. All cast iron pipes behave well in distilled or fresh waters. The rate of corrosion attack increases with the presence of salts in the water, aeration and temperature. When CI pipes are used in soft acid water the iron corrodes leaving behind a residue of graphite and iron oxide which is soft, porous and of low mechanical strength. Corrosion in steel pipes is more dangerous because of thinner wall sections used in steel pipes, when compared to CI pipes. Thus a suitable protective coating is a must for steel pipes. If proper protective coating is given corrosion resistance of pipes will not become a criterion for selection of pipe material among CI and steel pipes. For detailed discussion on corrosion and its prevention see Chapter 8.

Comparison of various metallic pipes is given in Table 1.

2.1 Cast Iron Pipes

There are three varieties in CI pipes based on their manufacturing process, Vertically Cast Pipes, Horizontally Cast Pipes & Centrifugally Cast Pipes.

Vertical casting in sand moulds is an age old process. But pipes manufactured by this process are not of very good quality (properties), as internal surface of pipes is not very smooth and there is a possibility for non uniforn thickness and defects which invariably result in certain percentage of rejection which is inherent in the process. The requirements for vertically cast iron pipes are covered in IS 1537 : 1976. In our country CI pipes are manufactured by horizontal casting also. This is similar to vertical casting except that the casting is done horizontally. The properties of these two are more or less similar. Only flanged type of pipes are manufactured in this process. The requirements for the horizontally cast pipes are covered in IS 7181 : 1986.

Now a days centrifugal casting (spun casting) is more popular. In this process pipes are cast with the spinning action of sand moulds or metallic moulds. The pipes produced by this process will have uniform thickness and texture, and more compacted grains compared to vertical casting. The spun process results in faster production, longer pipes with vastly improved metal quality, a smoother inner surface and reduced thickness and consequent light weight. The requirements for centrifugally cast iron pipes are covered in IS 1536 : 1989. The requirements for centrifugally cast low pressure pipes are covered in IS 6163 : 1978.

Because of its ease in manufacture, laying and jointing, the CI pipes are vastly used for water supply. They are well suited for pressure mains and laterals where tappings are made for house connections. Because of its thickness it can withstand external loads better than steel pipes.

CI pipes are heavy and thus the transportation costs are more and not suitable for laying in inaccessible places. Because of heavy weight these pipes are generally manufactured in shorter lengths than steel pipes, for easy handling and transportation. This increases laying and jointing costs. These pipes have low tensile strength and are liable to have defects of inner surface by virtue of their manufacturing process. Because of its brittleness and casting defects, CI pipes fail suddenly and damage caused is destructive.

These pipes are susceptible to corrosion effect. Hence it is preferable to give a protective coating. With protective coating these pipes are suitable for laying in slightly aggresive soils also. Coating shall not be applied to any pipe unless its surfaces are clean, dry and free from rust. Unless otherwise agreed between the purchaser and the manufacturer all pipes shall be coated externally and internally with the same material by dipping in a tar or suitable base bath. The pipes may be either preheated before dipping or the bath may be uniformly heated. Alternatively, if mutually agreed between the purchaser and the manufacturer, the pipes may be coated by spraying or brush painting. The coating material shall set rapidly with good adherence and shall not scale off. Where the coating material has a tar or similar base, it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 65°C but not so brittle at a temperature of 0°C as to chip off when scratched lightly with a penknife. The inside coating shall not contain any constituent soluble in potable water or any ingredient which could impart any taste or whatsoever to the potable water after sterilization and suitable washing of the mains. Pipes with or without sockets and flanges which are imperfectly coated or where the coating does not set or conform to the required quality, specified above the coating shall be removed and the pipes/flanges recoated.

Among CI pipes, centrifugally cast pipes are preferred due to the following reasons:

a) Spun pipes are about three fourth of the mass of vertically cast pipes of same class.
b) It has got greater tensile strength than other types of CI pipes because of its close grain structure which allows thin wall section.
c) Spun pipes have smoother inner surface.

2.2 Ductile Iron Pipes

Centrifugally cast ductile iron pipes are latest development in cast iron pipes. Molten metal treated with magnesium is used for producing these pipes. Adding magnesium based alloy to the molten metal gives a uniform distribution of nodular carbon graphites in casting, which improves the properties of the pipe to a great extent. Ductile iron pipes have got high mechanical strength and good impact resistance when compared to cast iron pipes. These pipes have high wear and tear resistance and smooth internal surface. These pipes are approximately 30 percent lighter than conventional CI pipes because of their reduced thickness due to high mechanical properties. The requirements for ductile iron pipes are covered in IS 8329 :1990. The requirements for ductile iron fittings for pressure pipes for water gas and sewage are covered in IS 9523 : 1980. These pipes are suitable for hydraulic working pressures up to 4 MPa (40 kgf/cm^2) depending on diameter. These pipes can be used where high stress concentrations are anticipated.

For the purpose of surface protection, these pipes are required to be coated during manufacturing stage. Except when otherwise agreed to between the purchaser and the manufacturer, all pipes shall be coated externally and internally with the same material, the pipes being preheated prior to total immersion in a bath containing a uniformly heated composition having a tar or other suitable base. The coating material shall set rapidly with good adherence and shall not scale off when the pipes are to be used for conveying potable water, the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or odour whatsoever to the potable water after sterilization and suitable washing of the mains.

2.3 Steel Pipes

Steel tubes are seamless or welded, made by one of the approved processes. The thickness of the steel pipe is controlled due to the need to make the pipe stiff enough to keep its circular shape during storage, transport, laying and also to take the load of trench back filling and vehicles.

The thickness of steel pipe is considerably less than the corresponding cast iron pipe owing to higher tensile strength of steel. Due to this property steel pipes can be manufactured in more than twice the length of CI pipes of same class, with consequent savings in transport, pipe laying and jointing costs. Due to their higher elasticity, steel pipes adapt themselves to changes in relative ground levels without failure. Hence they are suitable for laying on grounds liable to subsidence. Steel pipes, being flexible, are best suited for dynamic loads. Steel pipes maintain their mechanical properties over a wide variation of temperatures. Damage in transportation is minimal for steel pipes. Steel pipes are vastly used for water supply due to long established experience available which has developed confidence in the usage of these pipes.

The requirements for mild steel pipes up to 150 mm nominal diameter are covered in IS 1239 (Part 1) : 1990 and the requirements for mild steel and wrought steel fittings are covered in IS 1239 (Part 2) : 1991. These pipes can be jointed by means of socket and screw or by welding. The requirements for steel pipes with diameters greater than 150 mm are covered in IS 3589 : 1991. The requirements for spiral welded pipes are given in IS 5504 : 1969. Higher diameter steel pipes and spiral welded pipes are joined by welding only.

Corrosion badly affects the performance of steel pipes. Hence suitable protective coating is essential both internally and externally. Steel pipes are given cement mortar lining or epoxy coating or hot applied coal tar/asphalt lining in the factory or at site against internal corrosion. Recommendations for cement mortar lining for steel pipes are covered in IS 11906 : 1986.

Alternatively Mild Steel tubes may be galvanized during manufacturing for surface protection as per IS 4736 : 1986

Steel is a material ideally suited for welding and has got excellent mechanical properties. Hence steel pipes are best suited for long distance high pressure pipelines. Steel mains being light in weight are used for large diameters, especially above 900 mm, where CI pipes become very heavy and uneconomical.

3 CEMENT PIPES

Plain and reinforced cement concrete pipes, cylinder reinforced concrete pipes, prestressed concrete pipes and asbestos cement pipes come in the category of cement pipes. In all these pipes the bonding material used is cement. Generally ordinary portland cement conforming to IS 269 : 1989 is used in pipe manufacturing. But other varieties like portland slag cement, portland pozzolana cement, rapid hardening cement, hydrophobic portland cement and 43 grade Portland cement conforming to IS 455 : 1989, IS 1489 : 1991, IS 8041 : 1990, IS 8043 : 1978 and IS 8112 : 1989 respectively are also permitted for pipe making. Cement has good corrosion resistance properties. Hence the steel embeded in it is protected from corrosion. Greatest advantage of cement pipes over metallic pipes is their corrosion resistance. Because of this property, the water carrying capacity of pipes will not change much during their life. Cement pipes are bulky and heavy, and require careful transportation and handling. Cement pipes are not suitable where sulphates are present in the soil. Except for this, cement pipes have good chemical resistance properties. As these pipes are rigid, they require uniformly levelled bed for laying. In case of loose soils, which are susceptible to subsidence, proper care shall be taken for preparing the bed for laying these pipes. Cement pipes are suitable for water supply with low to medium range of pressures.

Comparison of characteristics of cement pipes is given in Table 2.

3.1 Cement Concrete Pipes

Concrete pipes are manufactured with or without reinforcement. Plain cement concrete pipes are used only for non-pressure purposes. All pressure pipes shall be reinforced. Cement concrete pipes are produced by centrifugal spinning or vibratory process or a combination of both. The pipes are to be cured in water or steam. RCC pipes cater to working pressures up to 0.3 MPa (3 kgf/cm^2) in case of pumping mains and 0.4 MPa (4 kgf/cm^2) in case of gravity mains. The requirements for cement concrete and reinforced cement concrete pipes are given in IS 458 : 1988. Bends junction and specials conforming to IS 7322 : 1985 shall be used with cement concrete pipes.

3.2 Steel Cylinder Reinforced Pipes

Steel cylinder reinforced concrete (SCRC) pipes are similar to RCC pipes; in addition to reinforcement a thin walled steel cylinder is used in the manufacture of the pipe, which increases the strength of the pipe. Ordinary RCC pipes are not suitable for carrying water at relatively high pressures. In such cases SCRC pipes are used. These pipes can be used for working pressures of 0.6 MPa (6 kgf/cm^2) to 2.0 MPa (20 kgf/cm^2).

The requirements for SCRC pipes are covered in IS 1916 : 1989 and the requirements for the specials used with SCRC pipes are covered in IS 7322 : 1985.

3.3 Pre-stressed Concrete Pipes

The pre-stressed concrete (PSC) pipes are manufactured by helically binding high tensile steel wire under tension around a concrete core, thereby putting the core in compression. When the pipe is pressurised, the stress induced in pipe will relieve/reduce the compressive stress caused by prestressing. Thus the concrete in PSC pipes will be under compression most of the time, which is a favourable factor for impermeability. Two types of PSC pipes are in use today — cylinder type and non cylinder type.

a) *Cylinder Type* — These pipes are manufactured in the following manner:

A welded sheet steel cylinder is lined with concrete suitably compacted and circumferentially prestresed to withstand internal pressure and external loads and subsequently coated with cement mortar to protect the steel cylinder and prestressing wires.

b) *Non-Cylinder Type* — These pipes are manufactured in the following manner :

A suitably compacted concrete core is longitudinally prestressed with pretensioned high tensile steel wire embeded in the concrete, circumferentially prestressed to withstand internal and extenal loads and subsequently coated with cement mortar or concrete to protect circumferential prestressed wire.

Prestressed concrete pipe is a unique combination of durability of concrete and high strength of steel combined with economy of raw materials. PSC pipes cater for intermediate pressure range for which metallic pipes are expensive and cement concrete pipes would not be possible. These pipes are ideally suited for water supply mains with a pressure range of 0.6 to 2.0 MPa (6-20 kgf/cm^2). These pipes economically compete with steel pipes for diameters 600 mm and above.

PSC pipes can not be cut to size to close gaps in the pipe-line. Special closure units are to be manufactured to the exact length. Even though PSC pipes are very good in strength and economy, the manufacturing of these pipes calls for skilled personnel and special machinery. Thus they can not be manufactured near to work sites, which results in higher transportation costs.

The requirements for PSC pipes and their specials are covered in IS 784 : 1978.

3.4 Asbestos Cement Pipes

Asbestos cement (AC) pipes are being used in our country for more than 50 years. These pipes are made of a mixture of asbestos fibre and portland cement compressed by steel rollers to form laminated material of great strength and density. These pipes have smooth internal surface and they will have more or less constant water carrying capacity through out their life. They are not affected by electrolytic corrosion. These pipes are light when compared to cement or PSC pipes. They can cater to working pressures up to 1.25 MPa (12.5 kgf/cm^2).Holes can be drilled in these pipes, thus, tappings can be made. These pipes are generally jointed by cast iron detatchable joints or by asbestos cement coller joints. Because of their corrosion resistance, smooth flow characteristics and suitability of pressure range these pipes are vastly used in rural water supply. These pipes can be used for rising mains as well as distribution mains.

The requirements for AC pressure pipes are covered in IS 1592 : 1989 and test methods for pipes are covered in IS 5913 : 1989. IS 9627 : 1980 gives the requirements of AC pressure pipes (light duty), which cater for working pressure up to 0.5 MPa (5 kgf/cm^2).

4 PLASTIC PIPES

4.1 Although the manufacture of plastic pipes was started in late thirties, fast development came during the second world war when there was a shortage of conventional materials. In India, plastic pipes had their begining in early sixties and made rapid strides in eighties. These pipes are available in two groups which are identified as thermoplastic and thermosetting materials. Unplasticised polyvinyl chloride (UPVC), polyethylene, polybutylene, acrylonitrile-butadiene styrene (ABS) etc, come under thermoplastic group whereas thermosetting polyester and epoxy are thermosetting. Among thermoplastic pipes, UPVC and polyethylene pipes are widely manufactured in India. The relevant specifications are given in Annex A.

NOTE — During the formulation of standards, extensive investigations were made which established that thermoplastic pipes are equally safe from bacteriological point of view as metallic pipes. Thermoplastic pipes are generally manufactured by extrusion moulding in continuous length. As the plastic extrusion comes from the die, it is cooled by water spray or immersion in water. The pipe is pulled through a traction unit or hauled off and finally cut to length by circular saw. Thermosetting pipes are generally manufactured by continuous filament winding process or centrifugal casting.

The properties, usage and suitability of widely used plastic pipes are discussed in the following paragraphs and comparison of properties of various plastic pipes is given in Table 3.

4.2 Unplasticised PVC Pipes

These are generally known as UPVC pipes or rigid PVC pipes. These pipes are light in weight, tough, exceptionally resistant to chemical attack and available in large lengths which reduce the cost of handling, transportation and installation. Lesser number of joints facilitates not only speed in laying of pipeline but also reduces the chances of leakage. These are immune to galvanic and electrolytic attack when burried in corrosive soils or near brackish water. UPVC pipes have good elastic properties and their adaptability to earth movement is superior compared to conventional pipe materials. Thermal conductivity of UPVC pipes is very low compared to metals, consequently water transported in these pipes remain at a more uniform temperature. Smooth internal surface of the pipes offers less friction which results in saving of energy in the conveyance of water. These pipes are recommended for water temperature ranging from 1 to 45°C. At higher temperatures up to 45°C, the strength of pipe reduces and the working pressure shall be modified in accordance with Fig. 1. Deterioration and decomposition of plastic pipes are accelerated by ultraviolet light and frequent changes in temperature which are particularly severe in our country. Deterioration starts with discolouration, surface crackig and ultimately ends with brittleness. Thus the life of the pipe is reduced. Further the coefficient of thermal expansion of UPVC pipes is eight times greater than steel pipes and therefore, provision shall be made when installed over the ground. The supports provided to the suspended pipes between the anchors shall not grip or distort the pipe but should allow the repeated longitudinal temperature movement to take place without abrasion. Line or point contact with the pipe should be avoided. Heavy components such as metal valves should be individually supported.

4.3 Polyethylene Pipes

Polyethylene pipes have good chemical resistance and are flexible, as such, a hard fall at the time of loading and inloading, etc, can not do any harm to it. These pipes can be easily bent in installation, eliminating the specials like bends, elbows, etc, at various locations, thereby reducing fittings and installation costs. Polyethylene pipes are not fractured by freezing and can be used up to ambient temperature of - 40°C. However, flow of water can be stopped due to freezing of water. Direct application of intense heat such as torch or open flame should not be used. Two grades of pipes are manufactured, namely, low density polyethylene (LDPE) pipes and high density polyethylene pipes (HDPE). Low density polyethylene pipes are highly flexible, can be coiled and are recommended for maximum water temperature of 38°C. These pipes have lower tensile strength than HDPE pipes whereas HDPE pipes are less flexible, tougher and at the same time they are resilient and also conform to topography of land when laid overground or in trenches. They can withstand movement of heavy traffic because of their flexural strength. These pipes are recommended for maximum water temperature of 45°C.

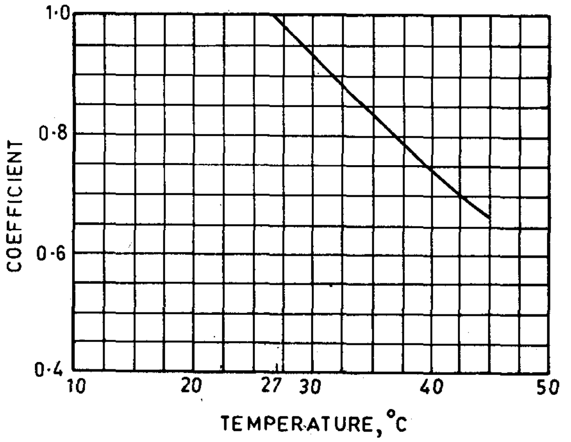

FIG. 1 GRAPH (FOR MORE PRECISE CALCULATIONS) GIVING THE MAXIMUM CONTINUOUS WORKING PRESSURE (COEFFICIENT) FOR TEMPERATURES UP TO 45°C

The creep rupture strength of the pipe diminishes with the increase in temperature above 27°C and working pressure should be modified as given in Fig. 2A and 2B for LDPE and HDPE pipes respectively. Polyethylene pipes also deteriorate in ultraviolet rays. Carbon black content of 2.5 ± 0.5 percent is added in the manufacture of these pipes for safeguarding against deterioration under ultraviolet rays. Further, there is a possibility of HDPE pipes passing the requirements stipulated in the standard (IS 4984 : 1987) even with adulterated material up to 30 to 40 percent. The effect of adulterated material shows only after the pipe is used for a few months. To safeguard this aspect melt flow index and density tests have been prescribed in IS 4984 : 1987 The other precaution to be taken while laying LDPE and HDPE pipes above ground is to provide adequate number of expansion loops, bellow or sliding gland expansion joints as the thermal expansion/contraction of LDPE and HDPE pipes are 20 times and 14 times respectively greater than metal pipes. Care should also be taken to account for the high increase in surface temperature of these pipes in cases of exposed laying or laying in proximity of artificial heat sources.

4.4 Thermosetting Plastic Pipes

These pipes are a matrix or composite of glass-fibre, thermosetting resin and fillers and are commonly known as GRP pipes. These are suitable for water distribution and are light in weight. With the range of thermosetting resins available, varying the constituents and different methods of manufacture, considerable variation is possible in the properties of pipe, in both resistance to corrosive environment as well as from structural point of view. Requirements of these pipes have been covered in IS 12709 : 1989. These pipes are not covered in detail in this manual because of their limited use in rural water supply at present.

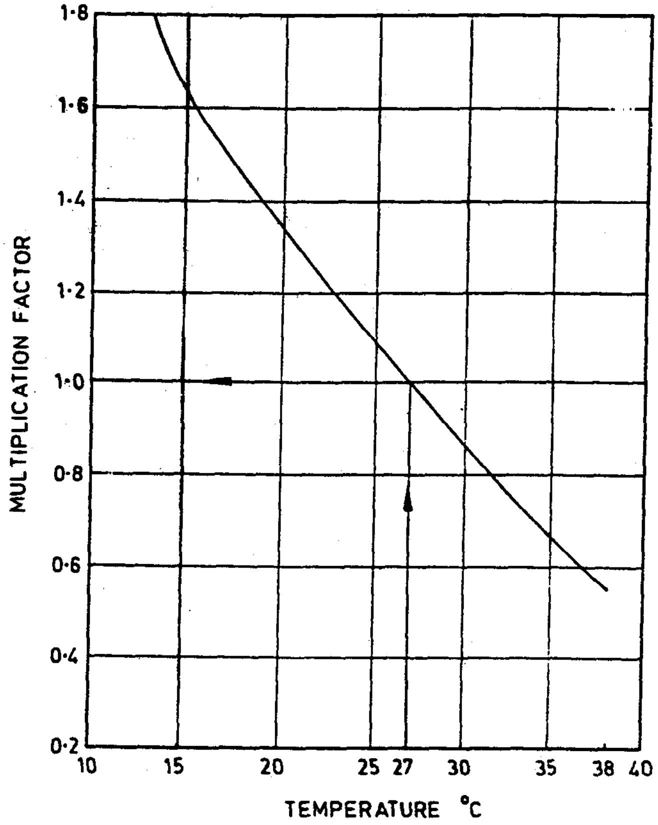

Fig. 2A Graph Giving the Maximum Continuous Working Pressure (Multiplication Factor) for Temperatures Up to +38°C

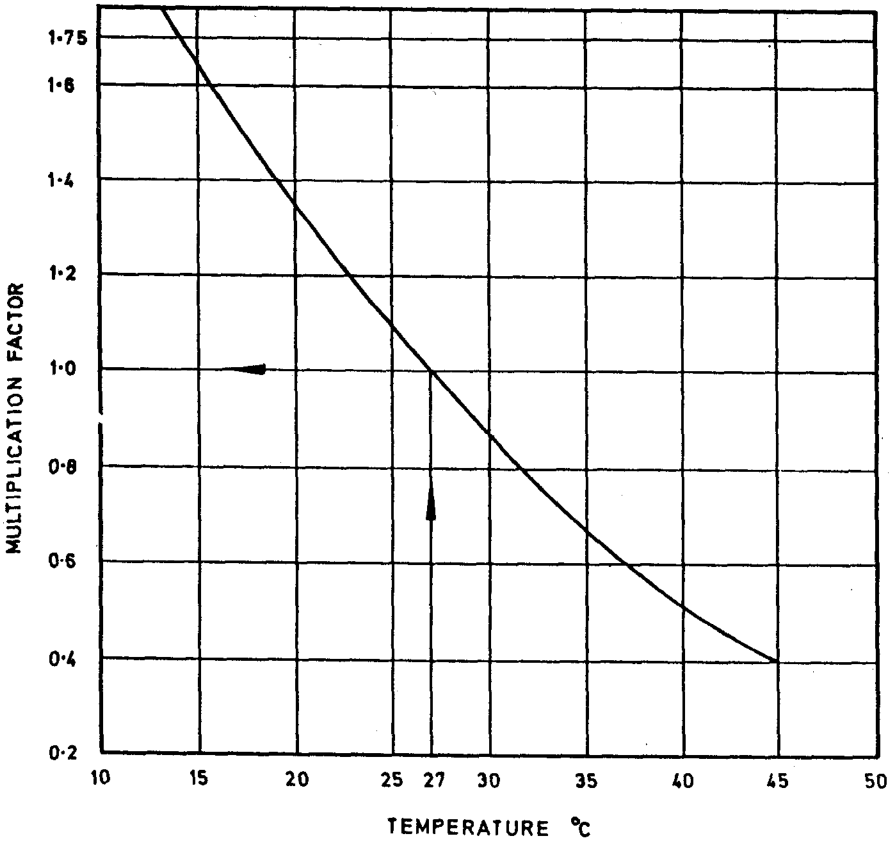

Fig. 2B Graph Giving the Maximum Continuous Working Pressure (Multiplication Factor) for Temperatures Up to 45°C

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Table 1 Comparison of Characteristics of Metallic Pipes

(*Clause* 2)

Sl. No.	Characteristics	Cast Iron Pipes												Steel Pipes				
		Verticially Cast IS 1537 : 1976				Horizontally Cast IS 7181 : 1986	Spun Cast IS 1536 : 1989				Spun Cast (LP) IS 6163 : 1978	Ductile Iron (Spun Cast) IS 8329 : 1990		Mild Steel (6 - 150 mm) IS 1239 (Part 1) : 1990			Mild Steel (168.3 to 2 032 mm OD) IS 3589 : 1991	
(1)	(2)	(3)				(4)	(5)				(6)	(7)		(8)			(9)	
i)	Jointing methods	Spigot and socket or flanged with compressed fibre board or rubber												Screwed and socketed			Butt welding or sleeve welding	
ii)	Application	Water supply, gas and sewage. Best suited for pressure mains and laterals where tappings are made for house connections										Water supply, gas and sewerage, Best suited where high stress concentration is anticipated		Water supply , steam, gas and air lines			Water supply, gas and sewerage	
iii)	Bends, junctions and specials	Covered in IS 1538 (Parts 1 to 24)										Covered in IS 9523 : 1980		Covered in IS 1239 (Part 2) : 1991 and IS 1879 : 1987			—	
iv)	Classification	Same as given in IS 1536 : 1989				Only Class B	Pipes have been classified as LA, and A and B according to their thickness. Class LA pipes have been taken as basis for evolving the series of pipes. Class A allows 10% increase in thickness over Class LA. Class B allows 20% increase in thickness over Class LA.				For low pressure (LP)	Classified based on mechanical properties, that is, percentage elongation, etc.		Depending on thickness			Based on mechanical properties Grade 320	Grade 410
v)	Hydrostatic test pressure, MPa	Spigot and socket pipes		Flanged pipes		Flanged only	Spigot and socket pipes			Flanged pipes	Spigot and socket only	Both spigot & socket and flanged pipes					$P = \frac{2S \times t}{D}$ Subject to *Max* of 5 MPa where P —test pressure in MPa, S — stress in MPa, 40% of minimum tensile strength (specified), t — specified thickness in mm, and D — specified outside diameter in mm (OD)	
	Nominal diameter (*DN*)	Class A	Class B	Class A	Class B	Class B	Class LA	Class A	Class B	Class B	Low pressure (LP)	Grade 1	Grade 2	Light	Medium	Heavy		
	Up to 300 mm	2.0	2.5	2.0	2.5	2.5	3.5	3.5	3.5	3.5	1.75	5.0	3.2	5	5	5		
	350 - 600 mm	2.0	2.5	1.5	2.0	2.0	3.5	3.5	3.5	2.0	1.75	4.0	3.2	—	—	—		
	700 - 1 000 mm	1.5	2.0	1.0	1.5	1.5	1.5	2.0	2.5	—	1.75	3.2	3.2	—	—	—		
	1 050 and above	1.0	1.5	1.0	1.0	—	1.5	2.0	2.5	—	—	—	—					
vi)	Nominal diameter, mm	80 to 1 500				80 to 750	80 to 1 050			80 to 600	80 to 750	80 - 1 000 (spigot & socket) 80 - 600 (flanged)		6 - 100	6 - 150	6 - 150	150 – 2 000	
vii)	Wall thickness, mm	7.9 – 33.9	8.6 - 37.0	7.9 - 33.9	8.6 - 37.0	10.0 - 25.6	7.2 - 23.6	7.9 – 26.0	8.6 - 29.0	8.6 - 19.0	4.9 - 14.6	6.0 - 13.5 (spigot & socket)	7.0 - 13.2 (flanged)	1.8 - 3.65	2.0 - 4.85	2.65 - 5.4	4.0 - 10.0	
viii)	Length, m	3.66 - 5.5[1]		2.0 - 4.0[1]		2.75 - 3.0	3.66 - 5.5			2.75 - 5.25	3.66 - 5.5	3.66 - 6.0 (spigot & socket)	2.75 - 6.0 (flanged)	As agreed to between purchaser and manufacturer (generally 6.0 m length)				
ix)	Mechanical properties																	
	a) 0.2% proof stress *Min.* MPa	—				—	—				—	300	300	—			—	
	b) tensile strength *Min.* MPa	150				150	For pipes cast in metal moulds 300 to 600 DN — 200 over 600 DN — 180		For pipes cast in sand mould of all diameters — 180		Same as for IS 1536 : 1989	420	420	320			320	410
	c) % elongation *Min.* on gauge length = $5.65\sqrt{S_0}$ (where S_0 = cross-section area of test piece)	—				—	—				—	10	5	6 – 25 mm dia 12 over 25 mm dia 20			20	18
	d) Modulus of rapture *Max*, MPa (ring test)	—				—	up to and including 300 mm DN — 400				Up to and including 300 mm nominal dia — 390	—		—			—	
	e) Brinell hardness *Max*, HB	210				230	230				230	230		—			—	
	f) *Max* permissible deviation from straight line, mm/m	1.25				1.25	1.25				1.25	1.25		—			—	
	g) Flattening test	—				—	—				—	Minimum vertical deformation shall be as given in 7.2 of IS 8329 : 1990		For tubes up to and including 50 mm nominal bore [for tubes as per IS 1239 (Part 1) : 1990] bend test is specified. For tubes above 50 mm nominal bore flattening test is specified for both IS 1239 (Part 1) : 1990 and IS 3589 : 1991 (ERW and seamless pipes). For EFW pipes as per IS 3589 : 1991 Guided bend test is specified.				

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[1] Except for 80 mm diameter pipe.

Table 2 Comparison of Characteristics of Cement Pipes

(*Clause* 3)

Sl No.	Characteristic	Cement Concrete and Reinforced Pipes IS 458 : 1988	Steel Cylinder Reinforced Concrete Pipes IS 1916 : 1989	Prestressed Concrete Pipes IS 784 : 1978	Asbestos Cement Pressure Pipes	
					IS 9627 : 1980 (light duty)	IS 1592 : 1989
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	**Common jointing method**	Flush jointing and collar jointing for non-pressure pipes; spigot and socket types for all classes of pressure pipes (with flexible rubber ring)	Spigot and socket type of joint or welded joint (butt weld or lap weld)	Spigot and socket joint with rubber sealing rings	Asbestos cement coupling with rubber sealing rings or cast iron detachable joints with rubber sealing rings	
ii)	**Bends, junctions and specials/fittings**	Shall conform to IS 7322 : 1985	Shall conform to IS 7322 : 1985	Shall conform to IS 784 : 1978	Cast iron specials for use in AC pipes shall conform to IS 5531 : 1988	
iii)	**Application**	NP pipes used for drainage and irrigation works P1 pipes for gravity mains and P2 and P3 pipes for pumping mains	Water mains, sewers, irrigation and similar works	Water mains and sewerage works (under pressure)	Water supply pressure mains	
iv)	**Classification**	NP1 to NP4 non-pressure pipes (test pressure 0.07 MPa) P1, P2 and P3 pressure pipes	Classification based on test pressure class 1 to class 5 and class (special)	Not classified as the pipes are to be designed as per field requirements	Classification based on test pressure Class 5 and 10	Class 5 to class 25 and Class 5 TP[1], to 10 TP[1]
v)	**Test pressure, MPa**	P1 P2 P3 0.2 0.4 0.6	Class 1 2 3 Pressure 0.5 1.0 1.5 Class 4 5 Special Pressure 2.0 2.5 >2.5	—	Class 5 10 Pressure 0.5 1.0	Class 5 10 15 20 Pressure 0.5 1.0 1.5 2.0 Class 25 5 TP[1] 10 TP[1] Pressure 2.5 0.5 1.0
vi)	**Nominal diameter, mm**	80 – 1 200 80 – 1 000 80 – 800	200 – 1 800	80 - 1 800	50 - 200	80 - 1 000[2] for class 5 to 25 and 700 - 1 000[2] for class 5 TP and 10 TP
vii)	**Wall thickness, mm**	25 – 65 25 – 100 25 – 120	40 – 70	As per design requirement	9.5 - 15.0	9.5 - 43.5, 9.5 - 43.5, 9.5 - 53.0, 11.0 - 71.5, 13.5 - 91.0, 24.5 - 34.5, 24.5 - 34.5 respectively for classes 5, 10, 15, 20, 25, 5TP, 10TP
viii)	**Length, m**	Up to 250 mm diameter : 2.0 above 250 mm diameter : 2.5-4	As agreed between purchaser and manufacturer	As agreed between purchaser and manufacturer	3, 4 or 5	3, 4 or 5
ix)	**Three edge bearing test** **a) load to produce 0.25 mm crack, kN/m** **b) ultimate load, kN/m**	a) 10.05 - 40.21 b) 15.08 - 60.32	—	a) 10 - 30 b) 16 - 45	—	—
x)	**Water Absorption**	*Max* 2.5% in first 10 min and *Max* 6.5% at the end of 24 hours	—	Permeability 1 cm³ in half an hour	—	—
xi)	**Hydraulic bursting stress, N/mm²**	—	—	—	10 for Class 5 12.5 for Class 10	80 to 300 mm dia — 20 350 mm dia and above — 22
xii)	**Transverse crushing stress N/mm²**	—	—	—	30	44
xiii)	**Longitudinal bending stress N/mm² (up to 150 mm dia)**	—	—	—	20	150 mm dia and less — 24.5 Above 150 mm dia — Not required

[1] TP is the test pressure.

[2] Pipes of nominal diameter larger than 1 000 mm may also be manufacturerd, in such cases, detailed dimensions may be arrived at between the supplier and the purchaser.

Table 3 Comparison of Characteristics of Various Plastic Pipes

(*Clause* 4.1)

No.	Characteristics	Polyethylene		UPVC	GRP
		LDPE IS 3076 : 1985	HDPE IS 4984 : 1987	IS 4985 : 1988	IS 12709 : 1989
(1)	(2)	(3)	(4)	(5)	(6)
i)	Chemical resistance	Good all round chemical resistance	Good all round chemical resistance	Good	Good
ii)	Flexibility	Highly flexible, can be coiled	Less flexible than LDPE, still pipes can be coiled	Relatively rigid	Rigid
iii)	Tensile strength	Low	Medium	Fair	High
iv)	Impact strength	Not applicable	Good	Fair	Very good
v)	Common jointing methods	Insert type joint, compression fittings and threaded joints	Insert type joints, compression fittings, fusion welding, threaded joints; flanged joints	Solvent welded joints, flanged joints	Double bell coupling, flanged joints, steel collar flanged joints and butt strap joints
vi)	Application	Water supply and distribution lines and internal plumbing of buildings	Underground water supply lines, also for plumbing in buildings, flexible water supply connections in buildings, river crossings, highly corrosive locations, marshy and saline areas.	For all applications like water services, (except for hot water), highly corrosive applications, plumbing in buildings, river crossings, marshy and saline areas.	For potable water supply, sewerage system for both above and below ground installations
vii)	Classification	Classification based on working pressure, Class 1 to Class 4	Classification based on working pressure, Class 1 to Class 5	Classification based on working pressure, Class 1 to Class 4	Classification based on working pressure, PN3 PN6 PN9 PN12 PN15
viii)	Working pressure 1) MPa (at 27°C)	0.25 0.40 0.60 1.00	0.20 0.25 0.40 0.60 1.00	0.25 0.40 0.60 1.00	0.3 0.6 0.9 1.2 1.5
ix)	Nominal outside diameter (OD) in mm	40 - 140 32 - 140 20 - 110 12 - 63	75–630 63–630 40–630 32–630 20–500	90 - 630 63 - 630 40 - 630 16 - 630	200 to 3 000
x)	Length nominal in m	25, 50, 100, 150 and 200 in coil form	In coils with minimum inner dia of coils as 25 times OD of pipe 2)	4, 5 and 6 m 2)	6 to 12 m 10% of pipe section may be supplied in random lengths
xi)	Recommended temperature range in °C (water temperature)	– 40 to +38	– 40 to +45	1 to 45	Can be used at temperature >43.5* (with reduced working pressure)
i)	Hydraulic characteristics a) Type test b) Acceptance test c) Quality test	Test temp. °C — Duration min — Induced stress MPa b) 70 — 100 — 2.9 c) 20 — 1 — 7.8	Test temp °C — Duration h — Induced Stress MPa a) 80 — 95 — 3.5 80 — 170 — 3.0 b) 80 — 48 — 4.1	Test temp °C — Duration h — Induced Stress MPa a) 60 — 1 000 — 10 b) 27 — 1 — 36	Class — 3PN 6PN 9PN 12PN 15PN Hydrostatic pressure in MPa for soundness test — 0.6 1.2 1.8 2.4 3.0
i)	Reversion test	Temp °C — Duration min — Permissible deviation in length percent 100 ± 2 — 60 — 3	Temp °C — Duration min — Permissible deviation percent 110 ± 3 — 30 — 3	Temp °C — Duration min — Permissible deviation in length percent 150 ± 2 — 15 to 60 (depending on thickness) — 5	—
xiv)	Tensile properties at 27 ± 1 °C	Wall thickness mm — Tensile strength *Min* — Elongation at break *Min* <5 — 8.85 MPa — 350% >5 — 8.85 MPa — 200%	—	—	—
)	Opacity	—	—	Wall of pipe shall not transmit more than 0.2% of visible light	—

Table 3 (*Concluded*)

Sl. No.	Characteristics	Polyethylene		UPVC	GRP
		LDPE IS 3076 : 1985	HDPE IS 4984 : 1987	IS 4985 : 1988	IS 12709 : 1989
(1)	(2)	(3)	(4)	(5)	(6)
xvi)	Effect on water	—	—	Mass, *Max.* Lead (first extraction) 1 ppm Lead (third extraction) 0.3 ppm Dyalkyle tin C_4 and higher homologous measured as tin (third extraction) 0.02 ppm Cadmium (all extracts) 0.001 ppm Mercury 0.001 ppm Other toxic substances (third extraction) 0.01 ppm	To be tested for migration of constituents of plastic material in accordance with IS 9845 : 1986 and potability should be estabilished
xvii)	Resistance to sulphuric acid	—	—	When tested according to IS 12235 (Part 6) : 1986 Mass of specimen shall not exceed 0.32 g nor decrease by more than 0.013 g	—
xviii)	Impact strength at 0ºC	—	—	When tested according to IS 12235 (Part 9) : 1986 no failure out of 14 strikes or up to 4 failures out of 42 strikes is considered as passing	—
xix)	Specific initial ring stiffness, percent	—	—	—	N/m^2 1 250 2 500 5 000 10 000 Ring Deflection Levels a) 18 15 12 9 b) 30 25 20 15
xx)	Beam strength, kN/m	—	—	—	Depends on diameter and class of pipe. Values are given in Table 3 of IS 12709 : 1989
xxi)	Hoop tensile strength, kN/m	—	—	—	Depends on diameter and class of pipe. Values are given in Table 4 of IS 12709 : 1989

[1] The working pressure shall be modified based on actual temperature to which the pipe will be subjected (*see* Fig. 1 and 2).

[2] The pipes may be supplied in other lengths where as agreed between the manufacturer and purchaser.

CHAPTER 3 TRANSPORTATION, HANDLING, STORAGE AND INSPECTION

1 METALLIC PIPES

1.1 Transportation

Pipes should be loaded in such a way that they are secured and that no movement should take place on the vehicle during transit.

The pipes should be loaded on vehicles in pyramid or straight sided formation. In case of pyramid loading the pipes in the bottom layer should be restrained by the use of broad wooden wedges secured to the vehicle being loaded. The pyramid is to be formed by resting pipes between the pairs of pieces in the preceding layer with the sockets in layers reversed. Straight sided loading may be used with supports along the sides of the vehicles. The use of straight sided loading is advantageous for utilizing full capacity of the vehicle.

1.2 Off-Loading

a) *Ductile Iron Pipes* — Cranes should be preferred for off-loading. However, for pipes up to 400 mm nominal bore, skid timber and ropes may be used.

When using mechanical handling equipment, it is necessary to employ sufficient personnel to carry out the operation efficiently with safety. The pipes should be lifted smoothly without any jerking motion and pipe movement should be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

Where the crane operator does not have a clear view, he should be guided by the personnel supervising the operation. When cranes are used, the whole sequence of operation should be carried out smoothly and without snap. Properly designed hooks and adequate stead ropes are essential. The hooks should be of suitable shape to ensure positive engagement when entered into the ends of the pipes and then should pass over any protective packing fitted around the pipe ends.

The use of slings passed around bundles of pipes is not recommended because bundles become unstable as the sling is drawn tight or released. However, when it is necessary to use the central slinging method for lifting single pipe, a broad webbing sling is recommended which minimizes the risk of the pipe slipping. Chain slings may slip and are dangerous.

b) *Cast Iron Pipes* — While unloading, pipes shall not be thrown down from the trucks on hard roads. Unloading them on timber skids without a steadying rope and thus allowing the pipes to bump hard against one another should not be allowed. In order to avoid damage to the pipes and specially to the spigot end, pipe should not be dragged along concrete and similar pavements with hard surfaces.

c) *Mild Steel Pipes* — It is essential to avoid damage to the pipes, fittings, specials, etc, at all stages during handling. The pipes and specials shall be handled in such a manner as not to distort their circularity or cause any damage to their outer coating. Pipes shall not be thrown down from the trucks nor shall they be dragged or rolled along hard surfaces. Slings of canvas or equally non-abrasive material of suitable width or special attachment shaped to fit the pipe ends shall be used to lift and lower coated pipes so as to eliminate the risk of damage to the coating.

1.3 Stacking

Pipes being taken to a stock ground for storage and held pending for further distribution should be arranged into stacks. The first layer of pipes should be laid on a firm foundation consisting of solid timber set level on the ground. Subsequent layers should be placed according to the method of stacking adopted. Care should be taken so that the pipes do not rest on their sockets. The height of any stack should not exceed 2 m.

1.3.1 Methods adopted for stacking of CI & ductile iron pipes are described in following paragraphs:

a) *Square stacking* — In square stacking methods, second and subsequent layers are set at right angles to the previous layers with spigots and sockets alternating in each layer and sockets project beyond spigot end. The pipes rest directly upon those beneath it and care is needed in placing to prevent damage.

b) *Parallel stacking with timbers* — All the pipes are parallel with the sockets of successive layers reversed end-to-end with sockets projecting beyond spigot end. Timber battens, placed about 600 mm from each end at right angles to the pipes, are used to separate the successive layers. Wedges at both ends of each batten prevent pipe movement.

c) *Nested stacking (pyramid stacking)* — Nested stacking consists of placing each pipe between the two pipes underneath it, with the sockets being all at one end of each layer and being reversed in successive layers. The bottom layer should be firmly anchored to prevent stack collapse.

d) *Special precautions for bitumen-sheathed pipes* — Bitumen-sheathed pipes should be handled with care to avoid any damage to the sheathing. They should not be stacked but laid in a single layer supported on timbers placed under the uncoated portions of the spigots and sockets. Sheathed pipes should be lifted by means of properly designed hooks fitting into the spigot or socket, or by specially designed slings which will not damage the sheathing. Wire rope, chains or hemp slings should not be used.

1.3.2 *Stacking of the Steel Pipes*

Steel pipes can be stacked in any one of the methods given in 1.3.1 (a) to (d). As steel pipes are plain ended the problem of arranging spigot and sockets will not be there. Padding shall be provided between coated pipes and timber skids to avoid damage to the coating. Suitable gaps in the pipes stacked shall be left at intervals to permit access from one side to other.

1.3.3 *Stringing*

Stringing consists of placing pipes on the ground in line ready for laying. Care should be taken to prevent damage during this operation.

1.4 Inspection

1.4.1 *Inspection of Cast Iron and Ductile Iron Pipes*

The pipes and fittings shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. Smearing the outer side with chalk dust helps the location of cracks. If doubt persists further confirmation may be obtained by pouring a little kerosene on the inside of the pipe at the suspected spot; if a crack is present the kerosene seeps through and shows on the outer surface.

If a pipe is mishandled either accidentally or due to carelessness during unloading or lowering operation it should be thoroughly inspected before laying and shall be rejected if found unsuitable by the authority.

1.4.2 *Inspection of Steel Pipes*

The pipes and specials shall be inspected and defects noticed, if any, such as protrusions, grooves, dents, notches, etc, shall be rectified. Care should be taken that the resulting wall thickness does not become less than the minimum specified. If the wall thickness becomes less than the minimum the damaged portion should be cut out as a cylinder and replaced by an undamaged piece of pipe.

A dent is a depression producing a significant alteration of the curvature of the pipe shell, the depth of a dent is measured as a gap between the lowest point of the dent and the curvature of the pipe-line. All dents exceeding 2 percent of the outer diameter of the pipe should be removed. Dents shall be removed by cutting out a cylindical portion of the pipe and replacing the same with an undamaged piece of the pipe. Insert patching may be permitted by the authority if the diameter of the patch is less than 25 percent of the nominal diameter of the pipe. Repairs by hammering with or without heating shall not be permitted. Any damage to the coating shall also be carefully examined and rectified.

2 CEMENT PIPES

2.1 Transportation

Pipes should be loaded at the works for transportation, either by rail or by road, in such a way that they are secure and that no movement can take place on the vehicle during transit. The same care is needed if pipes are to be transferred from one vehicle to another, however short the journey may be.

2.2 Off-loading

To avoid any costly manipulation or handling, the pipes shall be unloaded where they are required.

a) *Cement Concrete, SCRC, and Prestressed Concrete Pipes*

Off loading should be carried out by means of chain block with shear legs or crane of adequate capacity, using properly designed slings and spreader beams or specially designed lifting beams (*see* Fig. 1). Slings should be placed around the circumference of the pipe and should not be threaded through the pipe bore, as the latter method may damage the jointing surfaces. For the same reasons, hooks located in the ends of the pipes should not be used.

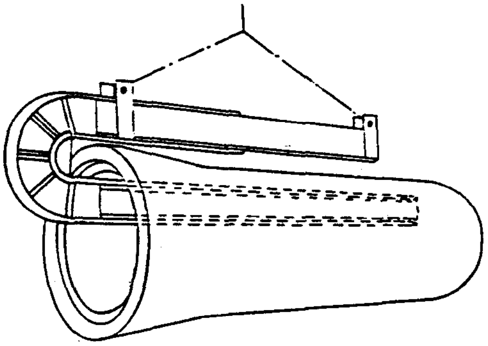

FIG. 1 A TYPICAL LIFTING BEAM

b) *Asbestos Cement Pipes (Except Where Mechanical Handling Facilities are available)* — Pipes weighing up to 60 kg shall be handled by two persons by hand-passing. Heavier pipes shall be unloaded from the lorry or wagon by holding them in loops, formed with ropes and sliding over planks set not steeper than 45°. The planks shall be sufficiently rigid and two ropes shall always be used to roll the pipes down the planks. The ropes should be tied on the side opposite to the unloading. Only one pipe shall be unloaded at a time.

Under no circumstances shall the pipes be thrown down from the carriers or be dragged or rolled along hard surfaces.

2.3 Stacking/Storing

a) *Cement Concrete, SCRC and PSC Pipes*

1) *Stacking* — Pipes may be placed directly on the ground provided it is reasonably level and free from rocks and other projections. Stacking in tiers is permissible provided timber bearers are placed between succeding tiers. If pipes are to be stacked more than two tiers high, reference should be made to the manufacturer for advice before exceeding the two tiers specified.

2) *Stringing* — Stringing consists of placing pipes on the ground in line ready for laying. Care is again needed to prevent damage during this operation.

b) *A.C. Pipes*

Each stack shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and cross-wise in alternate layers. The pyramid stack is advisable in smaller diameter pipes for conserving space in storing them. The height of the stack shall not exceed 1.5 m.

Cast iron detachable joints and fittings shall be stacked under cover and separated from the asbestos cement pipes and fittings.

Rubber rings shall be kept clean, away from grease, oil, heat and light.

2.4 Inspections

2.4.1 *Inspection of Pipes Before Laying*

Prior to being placed in the trench, pipes should be visually inspected for evidence of damage with particular emphasis laid on examination of the joint surfaces which may have been damaged by impact during transit or during off loading and handling at site.

2.4.2 *Repairing Damaged Concrete Pipes*

Any damage to the pipe may impair its strength or integrity consequently although some minor damage may be repairable at site, such repairs should be undertaken only by pipe manufacturer or under his supervision.

3 PLASTIC PIPES

3.1 Transportation

Plastic pipes are lighter than other varieties of pipes. Hence plastic pipes are easy to handle and transport. But they need careful handling and transportation as they are susceptible to damage.

Pipes should be loaded in such a way that they are secured and that no movement should take place on the vehicle during transport. Straight sided loading may be used with supports along the sides of the vehicle. The use of straight sided loading is advantageous for utilizing full capacity.

3.2 Handling

Because plastics are softer than metals they are more prone to damage by abrasion and by objects with cutting edge. Hence such practices as dragging pipes over rough ground should be avoided.

The impact strength of PVC pipes is reduced in cold weather. It makes the pipes brittle. Hence more care in handling shall be excercised in cold conditions. Polyethylene pipes are not affected by low temperatures and hence no additional care is required.

If due to unsatisfactory storage or handling, a pipe is damaged or kinked, the damaged portion should be cut out completely.

3.3 Storage

a) Polyethylene Pipes

Black polyethylene pipe may be stored either under cover or in the open. It is suitably protected from ageing due to sunlight by the addition of the appropriate quantity and type of carbon black. Natural polyethylene pipe, however, should be stored under cover and protected from direct sunlight.

Coils may be stored either on edge or stacked flat one on top of the other, but in either case they should not be allowed to come into contact with hot water or steam pipes and should be kept away from hot surface.

Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set.

Storage of pipes in hot areas should be avoided. While storing the pipes at temperatures above 45°C continuous support may be given by levelled sand layer or by other suitable methods.

b) PVC Pipes

The pipe should be given adequate support at all times. Pipes should be stored on a reasonably flat surface free from stones and sharp projections so that the pipe is supported throughout its length. In storage, pipe racks should provide continuous support and sharp corners of metal racks should be avoided. Pipes should not be stacked in large piles, especially under warm temperature conditions as the bottom pipes may distort, thus giving rise to difficulty in jointing. Socket and spigoted pipes should be stacked in layer with sockets placed at alternate ends of the stakcs to avoid lop sided stacks.

It is recommended not to store pipe inside another pipe. On no account should pipes by stored in a stressed or bent condition or near the sources of heat. In tropical conditions, pipes should be stored in shade.

Pipes should not be stacked more than 1.5 m high and pipes of different sizes and classes should be stacked separately.

The ends of the pipe should be protected from abrasion particularly those specially prepared for jointing either by spigot or socket solvent welded joints or shouldered for use with couplings.

CHAPTER 4 PIPE FITTINGS AND VALVES

1 Pipe fittings are the important component of pipelines. In practice it has been observed that most of the leaks occur at joints or at fittings and therefore due consideration should be given to the quality of fittings for proper functioning of pipe-lines.

1.1 Indian Standards on various types of fittings have been prepared to give guidance to the users. Table 1 covers the salient features of fittings as given in various Indian Standards. However, for comprehensive reference, respective standards should be referred to.

2 Valves are required in most water supply pipe lines to regulate flow of water. Valves are of different types depending on applications. Table 2 covers the salient features of some of the valves most commonly used in water supply lines. For comprehensive reference, respective Indian Standards should be referred.

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Table 1 Salient Features of Fittings

(*Clause* 1.1)

Sl No. (1)	IS No. (2)	Type of Fittings/Specials (3)	Range of Sizes (Nominal Diameter) Covered, mm (4)	Mass (kg) (5)	Tolerances on Sizes and Mass (6)	Raw Material, Manufacture Composition, Workmanship, etc (7)	Hydrostatic Test (8)	Remarks (9)
i)	IS 1538 (Part 1 to 24) : 1976	Socket and spigot of pipes	80 to 1 500	—	a) External diameter of spigot (lead joints) = $\pm \frac{1}{2} f$ or $\pm (4.5 + 0.001\,5\, DN)$ in mm b) Internal diameter of socket (lead joint) = $\pm \frac{1}{3} f$ or $\pm (3 + 0.001\, DN)$ where *DN* is the nominal diameter of fittings in mm and *f* is the caulking space of the joint in mm and is equal to (9.00 + 0.003 *DN*) mm c) Depth of socket (lead joint) i) up to and including 600 mm ± 5 mm ii) over 600 mm up to and including 1 000 mm ± 10 mm iii) over 1 000 mm, up to and including 1 500 mm ± 15 mm d) Thickness i) Wall – (2 + 0.05*e*) mm ii) Flange ± (3 + 0.5*b*) where *e* is the nominal thickness of the wall in mm and *b* is the nominal thickness of the flange in mm e) Length i) for socket fittings and flange and spigot pieces up to and including 450 mm dia ± 20 mm over 450 mm dia $^{+20}_{-30}$ ii) flanged fitting for all dia ± 10 mm f) Mass i) Bends, fittings with more than one branch ± 12% ii) for other fittings ± 8% g) Flanges i) Dia of flanges (mm) up to 250 mm + 3.0 − 1.0 above 250 mm + 5.0 − 1.5 ii) Dia between centre of bolt for flange dia up to 250 mm ± 1.0 above 250 mm ± 1.5 iii) Dia of holes for flange dia up to 300 mm + 2.0 − 0 above 300 mm + 3.0 − 0	The metal used for the manufacture shall be of quality not less than specified in IS 210 : 1978. The fitting shall be free from defects, other than unavoidable surface imperfection which result from the method of manufacture and which do not affect the use of fittings. The fittings shall be such that they could be cut, drilled or machined and may be accepted provided the hardness of the external unmachined surface does not exceed 210 HB. After inspection and hydrostatic test each fitting shall be coated, which shall be applied only to any fitting with surface clean, dry and free from rust. The coating material shall set rapidly with good adherence and shall not scale off. The standard specifies a coating test to check its adhesive properties also where coating material has tar or similar base. The inside coating shall not contain any constituent soluble in water or any ingredient which could impart any taste or odour whatsoever to the potable water after sterilization and suitable washing of mains.	a) Fittings without branches or with branches not greater than half the principal diameter : — Test Pressure MPa i) Up to and including 300 mm — 2.5 ii) Over 300 mm and up to and including 600 mm — 2.0 iii) Over 600 mm and up to and including 1 500 mm — 1.5 b) Fittings with branches greater than half the principal diameter i) Up to and including 300 mm — 2.5 ii) Over 300 mm and up to and including 600 mm — 2.0 iii) Over 600 mm and up to and including 1 500 mm — 1.0 The fittings are kept under pressure specified above for 15 seconds, these may be struck with a 700 gm hammer. The fittings shall withstand the pressure test without showing any leakage, sweating or other defects of any kind.	For double sockets tees mass up to 300 mm diameter of fittings has been specified.
		Sockets of fittings	80 to 1 500	—				
		Flanges of pipes and fittings	80 to 1 500	—				
		Raised flanges	80 to 1 500	—				
		Flanged sockets	80 to 1 500	13 to 1 463				
		Flanged spigot	80 to 1 500	12 to 1 456				
		Collar	80 to 1 500	14 to 1 261				
		Double socket bends						
		a) 1/4 Bends	80 to 1 500	18 to 4 951				
		b) 1/8 Bends	80 to 1 500	18 to 3 639				
		c) 1/16 Bends	80 to 1 500	16 to 2 652				
		d) 1/32 Bends	80 to 1 500	15 to 2 158				
		Tees, all	80 to 1 500	23 to 4 987				
		Double socket tees with flange branch	80 to 1 500 (Body) 80 to 250 (Branches)	22 to 129				
		Crosses, all sockets	80 to 300	30 to 197				
		Double socket tapers	80 × 100 to 1 200 × 1 500	—				
		Caps	80 to 1 500	7 to 1 342				
		Plugs	80 to 1 500	3 to 1 099				
		Bell mouth pieces	80 × 125 to 1 500 × 2 250	7 to 2 092				
		Double flanged bends						
		a) 1/4 bends	80 to 1 500	13 to 3 423				
		b) 1/4 duck foot bends	80 to 600'	31 to 677				
		c) 1/8 bends	80 to 1 500	14 to 2 460				
		All flanged tees	80 to 1 500	21 to 3 866				
		All flanged crosses	80 to 300	27 to 186				
		Double flanged tapers	80 x 100 to 1 200 × 1 500	12 to 1 198				
		Split puddle or body flanges	80 to 1 200	12.7 to 711				
		Blank flanges	80 to 1 500	5 to 1 110				
		All flanged radial tees	80 × 80 to 1 000 × 600					
ii)	IS 1879 : 1987	Elbows, male and female elbows, side outlet elbows	6 to 150	3.0 to 660.0 per 100 pieces	a) Where maximum and minimum dimensions are not specified, the tolerances for centre to face, face to face and centre to centre dimension shall be as under : *Dimensions* — *Tolerance* Above mm — up to and including mm — mm — — 30 — ± 1.5 30 — 50 — ± 2.0 50 — 75 — ± 2.5 75 — 100 — ± 3.0 100 — 150 — ± 3.5 150 — 200 — ± 4.0 200 — — — ± 5.0	The material used for the manufacture of malleable cast iron fittings shall conform to any of the grades specified in IS 2107 : 1977 or IS 2108 : 1977 as agreed to between the manufacturer and the purchaser. The fittings shall be galvanized to meet the requirements of IS 4759 : 1985. Outlets of fittings shall be threaded to dimensions and tolerances as specified in IS 554 : 1985. The axes of threads shall coincide with the theoretical axes of fitting within a tolerance of ± 1/2°. Besides a compression test to check malleability has also been specified.	The fittings shall be subjected to either of the two following pressure tests, as mutually agreed between the purchaser and the manufacturer. a) The application of an internal hydraulic pressure of not less than 2.1 MPa (21 kgf/cm²), or b) The application of air pressure of 1.05 MPa (10.5 kgf/cm²) whilst the fitting is completely immersed in water or light oil. The ends of the fittings when subjected to the required pressure, the ends of fittings after having been made up wrench tight with the prior application of lubricant, or sealent, or by any other appropriate method shall not show any leakage. The test shall be carried out after the fittings have been screwed and before any protective coating other than galvanizing has been applied.	
		Reducing elbows, reducing male and female elbow	up to 65 × 50	6.0 to 100.00 per 100 pieces				
		45° elbows, 45° male and female elbow	up to 50	5.3 to 50.0 per 100 pieces				
		Twin elbows	up to 50	12.7 to 140.0 per 100 pieces				
		Reducing twin elbows	up to 50 × 40 × 40	19.2 to 112.0 per 100 pieces				
		Union elbows (flat seat), male and female union elbows (taper seat)	up to 50	10.1 to 172.0 per 100 pieces				
		Tees and side outlet tees	up to 150	4.2 to 780.0 per 100 pieces				
		Reducing or increasing on the branch	up to 100 × 75 × 100	7.5 to 280.0 per 100 pieces				

Table 1 (*Continued*)

<table>
<tr><th>Sl No.
(1)</th><th>IS No.
(2)</th><th>Type of Fittings/Specials
(3)</th><th>Range of Sizes (Nominal Diameter) Covered, mm
(4)</th><th>Mass (kg)
(5)</th><th>Tolerances on Sizes and Mass
(6)</th><th>Raw Material, Manufacture Composition, Workmanship, etc
(7)</th><th>Hydrostatic Test
(8)</th><th>Remarks
(9)</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>b) *Thickness*
<table>
<tr><th>Basic size mm</th><th>Tolerance mm</th></tr>
<tr><td>2.0</td><td>− 0.5</td></tr>
<tr><td>2.5</td><td>− 0.5</td></tr>
<tr><td>3.0</td><td>− 0.7</td></tr>
<tr><td>3.5</td><td>− 0.7</td></tr>
<tr><td>4.0</td><td>− 0.7</td></tr>
<tr><td>4.5</td><td>− 1.0</td></tr>
<tr><td>5.0</td><td>− 1.0</td></tr>
<tr><td>6.0</td><td>− 1.0</td></tr>
<tr><td>6.5</td><td>− 1.0</td></tr>
<tr><td>7.0</td><td>− 1.0</td></tr>
</table>
NOTE — No limit for plus tolerance.
c) Permissible tolerances on nominal mass of fittings shall be $^{+15}_{-5}$ percent.</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Tees reducing on the run; reducing equal to or increasing on branch</td><td>50 × 50 × 40</td><td>9.7 to 75.8 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Pitcher tees</td><td>up to 50</td><td>11.6 to 129.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Reducing pitcher tees on the branch, reducing on the run; reducing on branch and run</td><td>up to 50 × 40 × 50</td><td>19.6 to 104.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Crosses</td><td>up to 100</td><td>8.8 to 380.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Crosses reducing</td><td>up to 50 × 40 × 50 × 40</td><td>12.3 to 78.5 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Bends, male and female bends</td><td>up to 50</td><td>5.3 to 99.3 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Long sweep bends, male and female long sweep bends and male long sweep bends</td><td>up to 100</td><td>3.3 to 565.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>45° long sweep bends and male and female 45° long sweep bends</td><td>up to 75</td><td>3.7 to 211.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Return bends</td><td>up to 50</td><td>17.7 to 141.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Socket, right and left hand thread socket, reducing and eccentric sockets</td><td>up to 150</td><td>2.2 to 340.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Male and female sockets and reducing male and female sockets</td><td>up to 50 × 40</td><td>3.8 to 40.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Bushing</td><td>up to 100 × 90</td><td>1.2 to 132.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Hexagon nipples, right and left hand thread and reducing hexagon nipples</td><td>up to 100</td><td>1.3 to 148.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Backnuts</td><td>up to 75</td><td>1.3 to 53.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Hexagon caps, round caps, plain plugs, beaded plugs & countersunk plugs</td><td>up to 100</td><td>1.2 to 132.0 per 100 pieces</td><td></td><td></td><td></td><td></td></tr>
</table>

Table 1 (*Continued*)

Sl No. (1)	IS No. (2)	Type of Fittings/Specials (3)	Range of Sizes (Nominal Diameter) Covered, mm (4)	Mass (kg) (5)	Tolerances on Sizes and Mass (6)	Raw Material, Manufacture Composition, Workmanship, etc (7)	Hydrostatic Test (8)	Remarks (9)
		Union (flat seat), male and female Unions (flat seat); Union (taper seat) and male and female Unions (taper seat)	up to 100	6.2 to 400.0 per 100 pieces				
		Gasket for unions (flat seat)	up to 100					
iii)	IS 9523 : 1980	PN 10 flanges PN 16 flanges PN 25 flanges (where PN is nominal pressure for fittings)	80 to 1 000 80 to 1 000 80 to 600	3 to 81.4 2.9 to 122.9 2.9 to 71.5	a) Tolerances on external diameter of the barrel, internal diameter and depth of socket for lead joint shall be as follows : *Dimension* — *Nominal Diameter* mm — *Tolerances* mm External diameter — All — $\pm \frac{1}{2} f$ or $\pm (4.5 + 0.0015\ DN)$ Internal diameter — All — $\pm \frac{1}{3} f$ or $\pm (3 + 0.001\ DN)$ Depth of socket — up to 600 — ± 5 over 600 and up to 1 000 — ± 10 over 1 000 and up to 1 800 — ± 15 where f is the caulking space of the joint in mm and equal to $9.9 + 0.003\ DN$ The jointing tolerances applicable to rubber joints [mechanical or push-in joint] shall be as specified by the manufacturer and shall be within the tolerances specified at (a) above. b) Tolerance on thickness in mm : i) Wall thickness $-(2.5 + 0.003\ DN)$ ii) Flange thickness $\pm (3 + 0.05\ b)$ where b is nominal thickness of the flange in mm c) Tolerance on length for socket, fittings and flange and spigot pieces i) up to 450 mm DN ± 20 mm ii) over 450 mm DN $^{+20}_{-30}$ mm iii) flange fittings ± 10 mm d) Mass i) Bends, fittings with more than one branch and non-standard fittings ± 12% ii) Other fittings ± 8%	The fittings shall be such that they could be cut, drilled or machined and shall be accepted provided the hardness of the external unmachined surface does not exceed the Brinnel hardness 250 HB. In case of flanged joints, the flange shall be at right angles to the axis of the joint and machined in face. The bolt holes shall be drilled. The two flanges of the fitting shall be correctly aligned. To control the quality of casting Tensile test and Brinnel Hardness test have been specified which are to be conducted on test bars cast. The coating requirement given in the standard are same as given above for cast iron fittings as per IS 1538 (Parts 1 to 38)	For hydrostatic tests, all fittings shall be kept under pressure for 15 seconds and may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. As far as possible, hydrostatic test shall be conducted before coating the fitting. All the fittings are tested for following hydrostatic pressure : *Nominal Diameter* mm — *Hydrostatic Test Pressure* Grade 1 MPa — Grade 2 MPa up to 300 — 6.0 — 3.5 300 to 600 — 5.0 — 3.5 700 to 1 000 — 4.0 — 3.5	
		Flanged sockets	80 to 1 000 for PN 10 and PN 16 class, 80 to 600 for PN 25 class	a) for PN 10 class 7.5 to 293 b) for PN 15 class 7.4 to 324 c) for PN 25 class 7.3 to 149				
		Flanged spigots	- do -	a) for PN 10 class 7.9 to 328 b) for PN 15 class 7.8 to 369 c) for PN 25 class 7.8 to 173				
		Collars	80 to 1 000	7.9 to 349				
		Double sockets 1/4 bends (90°)	80 to 300	8.6 to 68				
		Double sockets 1/8 bends (45°)	80 to 1 000	7.7 to 635				
		Double sockets 1/16 bends $22^1/_2$)	80 to 1 000	7.3 to 470				
		Double sockets 1/32 bends ($11^1/_4$°)	80 to 1 000	7.1 to 381				
		Double socket tees with flanged branch	80 to 1 000 for PN 10 and 16 80 to 600 for PN 25	a) for PN 10 class 13.6 to 1044 b) for PN 16 class 13.5 to 1086 c) for PN 25 class 13.5 to 380				
		All socket tees	80 to 200	12.4 to 43				
		Double socket tapers	100 to 1 000	8.5 to 354				
		Double flanged tapers	100 to 1 000 for PN 10 and 16 100 to 600 for PN 25	a) for PN 10 class 9.4 to 373 b) for PN 16 class 9.3 to 438 c) for PN 25 class 9.8 to 216				
		Blank flanges	80 to 1 000 for PN 10 and 16 80 to 600 for PN 25	a) for PN 10 class 3.6 to 293 b) for PN 16 class 3.5 to 387 c) for PN 25 class 3.5 to 144				
		Reducing flanges	200 to 1 000 for PN 10 and PN 16 class 200 to 400 PN 25 class	a) for PN 10 class 13.3 to 209 b) for PN 16 class 13.0 to 260 c) for PN 25 class 15 to 60				

Table 1 (*Continued*)

S No. (2)	Type of Fittings/Specials (3)	Range of Sizes (Nominal Diameter) Covered, mm (4)	Mass (kg) (5)	Tolerances on Sizes and Mass (6)	Raw Material, Manufacture Composition, Workmanship, etc (7)	Hydrostatic Test (8)	Remarks (9)
	Double flanged 1/4 bend (90°)	80 to 1 000 for PN 10 and 16 class 80 to 600 for PN 25 class	a) for PN 10 class 9.9 to 907 b) for PN 16 class 9.6 to 990 c) for PN 25 class 9.6 to 253				
	Double flanged 1/4 Duckfoot bend (90°)	80 to 600	a) for PN 10 class 14.3 to 428 b) for PN 16 class 14.1 to 481 c) for PN 25 class 14.1 to 509				
	Double flanged 1/8 bend (45°)	80 to 1 000	a) for PN 10 class 9.5 to 668 b) for PN 16 class 9.3 to 751 c) for PN 25 class 903 to 294				
	Flanged tees	80 to 1 000 for PN 10 and PN 16 class 80 to 600 for PN 25 class	a) for PN 10 class 16 to 1 105 b) for PN 16 class 15.6 to 1 229 c) for PN 25 class 15.6 to 477				
rt 2) : 1991	Pieces	6 to 150	—	a) When maximum and minimum dimensions are not specified, the tolerances for centre to face, face to face and centre to centre dimension shall be as under : *Dimension* (mm): Above / Up to and including — *Tolerances* (mm) — / 30 — ± 1.5 30 / 50 — ± 2.0 50 / 75 — ± 2.5 75 / 100 — ± 3.0 100 / 175 — ± 3.5 NOTES 1 Centre to face dimension apply to elbows, bends, tees, crosses, etc. 2 Face to face dimensions apply to sockets, nipples, etc. 3 Centre to centre dimensions apply to return bends b) The axis of the thread shall be coincident with the theoretical axis of the fittings within a tolerance of ±0.5° on the run and on the branches.	Tubulars shall be made from tubes which comply with all the appropriate requirements of IS 1239 (Part 1) : 1990. Sockets shall be manufactured from mild steel by any of the following process : a) Hot finished seamless (HFS), b) Electric resistance welding (ERW), c) High frequency induction welded (HFIW), and d) Hot-finished welded (HFW). Hand welding of sockets may be permitted provided test requirements for sockets covered in IS 1239 (Part 2) : 1991 are complied with. Other fittings shall be manufactured from mild steel by any approved process. Unless otherwise specified by the purchaser, all fittings shall be manufactured with thread connections, complying with the requirements of IS 554 : 1985. The steel from which fittings are made when tested in accordance with IS 1894 : 1972 shall show a minimum tensile strength of 320 MPa. The percentage elongation on a gauge length of $5.65 \sqrt{S_o}$ (where S_o is the original corss-section of the test specimen) shall not be less than 9 500 divided by the tensile strength of specimen. The ladle analysis of steel shall not show sulphur and phosphorus content exceeding 0.06 percent each. The maximum permissible variation of sulphur and phosphorus in case of product analysis from this limit shall be 0.005 percent each (product analysis is not applicable to rimming quality steel). Where fittings are to be galvanized, the zinc coating shall be in accordance with IS 4736 : 1986. Tubulars sockets and fittings shall be cleanly finished and reasonably free from scale, surface flaws, lamination and other defects. The screw threads shall be clean and well cut. The ends shall be cut clearly and square unless otherwise specified. For sockets the standard also specifies expansion test (Drift Expanding Test or Taper Screw Plug Test).	*Pressure Tests* : The fittings and sockets before they leave the works shall be subjected to either of the following tests, as mutually agreed between the purchaser and the supplier. i) The application of an internal hydraulic pressure of 5 MPa (50 kgf/cm²); and ii) Application of an internal air pressure of 0.7 MPa (7.0 kgf/cm²) while the fitting is completely immersed in water or light oil. The ends of fittings and sockets when subjected to the required pressure, after having been made up wrench tight with the prior application of lubricant, or sealant, or by any other appropriate method shall not show any leakage. The test shall be carried out after the fittings and sockets have been screwed and before any projecting coating other than galvanizing has been applied. The sample size and acceptance criteria for pressure test shall be as given IS 1239 (Part 2) : 1991.	
	Running nipples, close taper, nipples and barrel nipples	6 to 150	—				
	Long Screws	6 to 150	—				
	Bends and springs	6 to 150	—				
	Return bends	6 to 150	—				
	Sockets	6 to 150	—				
	Elbow tees and crosses, equal	6 to 150	—				
	Elbows, reducing	8 × 6 to 100 × 80					
	Reducing tees (on the branch)	8 × 6 to 150 × 100	—				
	Tees, reducing (on the run and branch or on the run only)	20 × 15 × 15 to 100 × 80 × 80	—				
	Tees increasing on branch	6 × 8 to 80 × 100	—				
	Crosses, reducing	8 × 6 to 150 × 100	—				
	Elbows, round, male and female, equal	8 to 100	—				
	Elbows, equal 135°	6 to 100	—				
	Elbows, tees and crosses, side outlet, equal	15 to 50					
	Y-pieces, female, equal	15 to 100	—				
	Socket reducing	8 × 6 to 40 × 32	—				
	Caps	6 to 150	—				
	Plugs	6 to 150	—				
	Elbows, tees crosses, male, equal	15 to 150	—				
	Y-pieces and angle tees; male, equal	15 to 150	—				

Table 1 (*Continued*)

Sl No. (1)	IS No. (2)	Type of Fittings/Specials (3)	Range of Sizes (Nominal Diameter) Covered, mm (4)	Mass (kg) (5)	Tolerances on Sizes and Mass (6)	Raw Material, Manufacture Composition, Workmanship, etc (7)	Hydrostatic Test (8)	Remarks (9)
		Twin elbows and sweep tees, male, equal	15 to 150	—				
		Socket unions	6 to 150	—				
		Pipe unions	6 to 150	—				
		Union bends	6 to 80	—				
		Hexagon, bushes	8 to 150	—				
		Nipple, hexagon, equal	6 to 150	—				
v)	IS 7322 : 1985	Bends, 30° to 90°	200 to 1 800	—	a) Arm length ± 40 mm b) Arm length (specified) ± 10 mm c) Internal diameter i) 300 mm and under ± 3 mm ii) over 300 mm ± 6 mm or ± 1½% whichever is less d) Angular deviation ± 1°	Details of the material are given in the standard. These pipes are designed such that the maximum tensile stress in the reinforcement under the specified hydrostatic test pressure does not exceed 200 MPa (2000 kgf/cm²) assuming that no tension is taken up by the concrete. The minimum thickness of plate for steel shall be as under : *Nominal Internal dia of Finished shell* mm — *Min. thickness of Plate* mm 200 to 500 — 2.5 600 to 900 — 5.0 1 000 to 1 100 — 6.0 1 200 to 1 500 — 8.0 1 600 to 1 800 — 10.0 The standard gives details of manufacture of steel core, reinforcement cage, concreting and curing. The specials shall be free from cracks. The ends shall be square with their longitudinal axis at that point, so that when actually placed in site trench, no opening between ends in contact shall exceed 3 mm in specials up to 600 mm diameter and 6 mm in specials larger than 600 mm diameter. The inside and outside surface shall be smooth, dense and hard and shall not be coated with cement wash or other preparations unless otherwise agreed to between purchaser and manufacturer. These shall be free from local dents or bulges greater than 3.00 mm in depth and extending over a length in any direction greater than twice the thickness of the barrel. The unlined special shall be tested by dye penetration test in accordance with IS 3658 : 1981 or other approved means		
		Tees	200 to 1 800	—				
		Scour tees	Dimensions as per IS 1916 : 1989					
		Reducer	- do -					
		Standard flanges	200 to 1 800	—				
vi)	IS 5531 : 1988	Bends			a) Thickness i) wall thickness - (2.0 mm + 0.05*e*) ii) Flange thickness ± (3.00 + 0.05*b*) where *e* is nominal thickness of the wall in mm and *b* is the nominal thickness of the flange in mm. There is no limit for plus tolerances b) Other dimensions : *Dimensions* mm — *Tolerances* mm i) Machined outside dia + 1.5 − 1.0 ii) Length & height + 15 − 10 c) Mass : i) for bends and fittings with more than one branch ± 12 percent ii) other fittings ± 8 percent	Same as for IS 1538 (Part 1 to 24)	The specials shall be tested for hydraulic test pressure specified in IS 1592 : 1989. The method of test is same as given at Sl. No. (i) of this table.	
		a) 90°	80 to 600	7.6 to 495				
		b) 45°	80 to 600	7.7 to 380				
		c) 22½°	80 to 600	5.7 to 267				
		d) 11¼°	80 to 600	4.7 to 210				
		Plain end plugs	80 to 600	3.4 to 234				
		Plain end reducers	100 × 80 to 600 × 500	8.3 to 257				
		Crosses	80 to 600	12.2 to 951				
		Plain ended flanged spigot	80 to 600	7.4 to 188				
		Plain ended tees	80 to 600	9.7 to 780				
		Plain ended wyes	80 to 600	14.7 to 900				
vii)	IS 8794 : 1988	Flanges	80 to 600		a) Wall thickness of collars — (1 + 0.05 *t*) No limit for plus tolerance b) Cored holes and other dimensions in mm ± 2.0 for *DN* up to 300 mm ± 2.5 for *DN* above 350 mm c) Drilled holes ± 1.5 mm Where *t* is nominal thickness in mm and *DN* is nominal diameter of pipe in mm.	The metal used for the manufacture of joints shall be of requisite quality conforming to any grade of IS 210 : 1978. The details of the coating have been given in the standard.	Hydrostatic tests shall be carried out for collars only. For this collars shall be kept under pressure for 15 seconds, minimum; it may be struck moderately with a 700 g hammer. It should withstand the pressure test without showing any leakage or sweating and other defects of any kind. This test as far as possible shall be conducted before coating the collars. The collars shall withstand the hydrostatic test pressure specified for asbestos pipes in IS 1592 : 1989 for the class of pipe with which they are to be used.	
		Collars	80 to 600					

Table 1 (*Continued*)

Sl No.	IS No.	Type of Fittings/Specials	Range of Sizes (Nominal Diameter) Covered, mm	Mass (kg)	Tolerances on Sizes and Mass	Raw Material, Manufacture Composition, Workmanship, etc	Hydrostatic Test	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
viii)	IS 10299 : 1982	Saddle Piece	80 to 200	1.7 to 3.9	a) Cored holes and other dimensions ± 2 mm b) Drilled holes ± 1.5 mm c) Mass (excluding rubber gasket and bolts) — 5 percent NOTE — No limit for plus tolerance.	Same as for IS 1538 (Part 1 to 24) : 1976 given at S. No. (i).	Hydrostatic test has not been prescribed.	
ix)	IS 8008 (Part 1 to 7) : 1976	90° Tees	20 25 32 40 50 63 75 90 110		Laying length and tolerances 25 ± 1 mm 30 ± 1 mm 37.5 ± 1 mm 45 ± 2 mm 50 ± 2 mm 58.5 ± 2 mm 84 ± 2 mm 98.5 ± 2 mm 122.5 ± 3 mm	These fittings are made by injection moulding from Virgin polyethylene in which carbon black (2.5 ± 0.5 percent by mass) and a suitable toxic anti-oxidant is evenly dispersed. The standard allows 10 percent of the manufacturer's own rework material. Melt flow index is specified as 0.4.	Hydraulic test is conducted in the fittings in a similar method as conducted on HDPE pipes for internal pressure creep rapture test given in IS 4984 : 1987. The fittings are also tested for reversion test as prescribed for HDPE pipes in IS 4984 : 1987 and dimensions shall not change by more than 3 percent in the longitudinal direction.	
		90° bends	20 25 32 40 50 63 75 90 110		35 ± 1 mm 40 ± 2 mm 50 ± 2 mm 60 ± 2 mm 70 ± 2 mm 80 ± 2 mm 90 ± 2 mm 110 ± 2 mm 140 ± 2 mm			
		Reducers	32 × 63 63 × 75 63 × 90 75 × 90 90 × 110 110 × 160 160 × 225		60 ± 2 mm 70 ± 2 mm 80 ± 2 mm 80 ± 2 mm 100 ± 2.5 mm 140 ± 3 mm 200 ± 3.5 mm			
		Ferrule reducers	32 × 63 90 × 63 110 × 63 160 × 63 225 × 63		48 ± 2 mm 74.3 ± 2 mm 89.4 ± 2 mm 98.5 ± 2 mm 102.8 ± 2.5 mm			
		Pipe ends	20 to 225		16 ± 1.5 mm to 50 ± 1.5 mm (for other details *see* standard Part vi)			
		Sandwich flanges	20 to 225		20 ± 1.5 to 25 ± 1.5 mm (for other details *see* standard Part vii)			
x)	IS 8360 (Part 1 to 3) : 1977	90° tees	20 to 500		Laying length and tolerances ranges from 50 ± 2 to 750 ± 10 mm	The material is same as specified in LDPE pipe standard (IS 4984 : 1987).	The fittings are subject to a hydraulic proof test of twice the recommended working pressure at ambient temperatures for a period of one hour. The fittings shall not show any sign of localized swelling, leakage or weeping and shall not burst during the test.	
		90° bends	20 to 500		Laying length and tolerances ranges from 100 ± 3 to 855 ± 12 mm			
xi)	IS 7834 (Part 1 to 8) : 1977	Sockets	16 to 315		a) Out of roundness tolerance of socket inside dia is 0.007 D in mm or 0.2 mm, whichever is more where D is diameter in mm b) The maximum and minimum dimension of mean diameter at mid-point of socket depth shall comply with Table 1 of IS 7834 (Part 1) : 1987 c) For tolerances on other dimensions for fittings, *see* respective parts of IS 7834.	Fittings are made of PVC to which may be added only those additives that are needed to facilitate the manufacture of sound pipe of good surface finish; mechanical strength and opacity. The fittings are tested for stress relief test, opacity and effect on water.	Fittings are tested for short term hydraulic test and shall withstand a pressure of 4.2 times the working pressure for one hour without failure.	
		45° Elbows	16 to 315					
		90° Elbows	16 to 315					
		90° Tees	16 to 315					
		45° Tees	16 to 160					
		Unions	16 to 63					
		Caps	16 to 315					

Table 1 (*Continued*)

Sl No.	IS No.	Type of Fittings/Specials	Range of Sizes (Nominal Diameter) Covered, mm	Mass (kg)	Tolerances on Sizes and Mass	Raw Material, Manufacture Composition, Workmanship, etc	Hydrostatic Test	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
xii)	IS 10124 (Part 1 to 13) : 1988	Sockets	63 to 630		a) Out of roundness of socket inside dia for all fittings is same as given at Sl. No. xi) b) The maximum and minimum dimensions of mean diameter at mid-point of socket depth shall comply with those given in IS 10124 (Part 1) : 1988 c) For tolerences on other dimensions for fittings, *see* respective parts of IS 10124	The material of manufacture shall conform to the material given for UPVC pipes (IS 4985 : 1988). Test for opacity has also been prescribed which conforms to the test given for UPVC pipes (IS 4985 : 1985).	Method of hydraulic test is same as specified for injection moulded PVC fittings at S. No. xi) of this table.	Out of roundness tolerences of socket insi shall not apply to fittings of nominal pres 0.25 MPa (class 1), 0.4 MPa (class 2) an (class 3)
		Straight reducers	20 to 15 to 630 to 560					
		Caps	63 to 630					
		Equal tees	63 to 630					
		Flanged tail pieces with metallic flanges	63 to 630					
		Threaded adaptors	63 to 110					
		90° bends	63 to 630					
		60° bends	63 to 630					
		45° bends	63 to 630					
		30° bends	63 to 630					
		$22\frac{1}{2}^\circ$ bends	63 to 630					
		$11\frac{1}{4}^\circ$ bends	63 to 630					
xiii)	IS 2692 : 1989	Ferrules	8, 10, 15, 20, 25, 32, 40 and 50 mm. Nominal size of ferrule shall be designated by nominal bore of inlet connection.		Refer to IS 2692 : 1989	Material for different parts of ferrule shall be as given in Table 1 of IS 2692 : 1989. *Manufacture, Workmanship* All castings shall be sound, free from laps, blow holes and pittings and both the external and internal surfaces shall be clean, smooth and free from sand. They shall be neatly dressed and no casting shall be burnt, plugged, stopped or patched. Bodies, plugs and other parts shall be truly machined so that when assembled the parts shall be axial, parallel and cylinderical with surfaces smoothly finished.	Every ferrule, complete with its component parts, shall withstand a hydraulic pressure of at least 1.5 MPa, applied for 2 minutes and during this period it shall neither leak nor sweat.	

NOTE — No Indian Standard exists for low density Polyethylene (LDPE) pipe fittings. However, for LDPE pipe joints, the details of jointing techniques are given in IS 7634 (Part 2) : 1975.

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Table 2 Salient Features of Valves

(*Clause* 2)

Sl No.	IS No., Title	Classification/ Designation	Types	Nominal Sizes (mm)	Hydrostatic Test Pressure and Duration	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	IS 778 : 1984 Specification for copper alloy gate globe and check valves for water works purposes	a) Class 1 Valves — Suitable for non-shock cold working pressure upto 1.0 MPa (cold service means a temperature not exceeding 45°C) b) Class 2 Valves — Suitable for non-shock cold working pressure upto 1.6 MPa.	a) Gate valve (having inside screw with rising or non-rising stem or outside screw with rising stem) shall be of following types : i) Solid wedge type ii) Split wedge type iii) Double disc type	a) Screwed end valves — $8(\frac{1}{4})$, $10(\frac{3}{8})$, $15(\frac{1}{2})$, $20(\frac{3}{4})$, 25(1), 32 $(1\frac{1}{4})$, $40(1\frac{1}{2})$, 50(2), 65 $(2\frac{1}{2})$, 80(3), and 100 (4) The nominal sizes in parenthesis are sizes according to IS 554 : 1985.	Class of valve / Test / Test Pressure *Min* (MPa) / Test Duration *Min* (minutes) Class 1 / Body test / 1.5 / 2 Class 1 / Seat test / 1.0 / 2 Class 2 / Body test / 2.4 / 2 Class 2 / Seat test / 1.6 / 2 NOTE — In back seat test (applicable to gate and globe only) test pressure shall be same as that for seat test.	
			b) Globe valves (having rising stem with inside or outside screw) shall be of following types : i) Straight type, and ii) Right angle type	b) Flanged valves — 15, 20, 25, 32, 40, 50, 65, 80 and 100 mm.		
			c) Check valves i) Swing type (for use with the axis of the body end ports horizontal or vertical) ii) Lift type with disc or ball check (for use with the axis of the body end ports horizontal or vertical or in applications where the axis of the body end ports are at right angles).			Swing check valves may also be used in vertical direction when the flow is in upward direction.

Table 2 (*Continued*)

Sl No. (1)	IS No., Title (2)	Classification/ Designation (3)	Types (4)	Nominal Sizes (mm) (5)	Hydrostatic Test Pressure and Duration (6)				Remarks (7)
ii)	IS 780 : 1984 Specification for sluice valves for water works purposes (50 to 300 mm sizes)	PN 1 and PN 1.6 where PN is the nominal pressure — Maximum permissible gauge working pressure in MPa	Non-rising stem type	50, 60, 80, 100, 125, 150, 200, 250 and 300 mm. These sizes refer to the nominal bore of the water way. The actual bore at any point shall not be less than the nominal sizes.	PN Rating of Valve	Test	Test Pressure (Gauge) *Min* (MPa)	Test Duration *Min* (minutes)	
					PN 1	Body test	1.5	5	
						Seat test	1.0	2	
					PN 1.6	Body test	2.4	5	
						Seat test	1.6	2	
iii)	IS 781 : 1984 Specification for cast copper alloy screw down bib taps and stop valves for water services	Suitable for cold non-shock working pressure upto 1.0 MPa (cold service condition means a temperature not exceeding 45°C).	—	Bib taps - 8, 10, 15, 20 and 25 mm Stop Valves - 8, 10, 15, 20, 25, 32, 40 and 50 mm. These nominal sizes are the nominal bores of socket or pipe outlet to which the tap or valve is normally fitted.	When tested complete with its components Internal hydraulic pressure — 2 MPa, *Min* Test duration — 2 minutes, *Min*				Bib taps shall have screwed male ends. Stop valves shall have screwed female ends or male ends or mixed ends.
iv)	IS 1711 : 1984 Specification for self closing taps for water supply purposes	—	Self closing taps may be with or without stuffing box.	15 mm and 20 mm where nominal size refers to nominal bore of inlet connection.	Tested in assembled condition with its components with internally applied hydraulic pressure of 2 MPa *Min* for a duration of 2 minutes, *Min*.				—
v)	IS 2906 : 1984 Specification for sluice valves for water works purposes (350 to 1200 mm size)	Designated by nominal pressure PN (*see* Sl. No. 2, Col 3) for the sizes indicated below. *Nominal Pressure* MPa *Nominal Size* mm PN 0.4 700 to 1200 PN 0.6 350 to 1200 PN 1.0 350 to 1200 PN 1.6 350 to 600	Non-rising stem type	350, 400, 450, 500, 600, 700, 750, 800, 900, 1000, 1100 and 1200 (*see* Sl No. 2, Col 5 for definition of nominal size)	PN Rating	Test	Test Pressure *Min* (MPa)	Test Duration *Min* (minutes)	—
					PN 0.4	Body test	0.6	5	
						Seat test	0.4	2	
					PN 0.6	Body test	0.9	5	
						Seat test	0.6	2	
					PN 1.0	Body test	1.5	5	
						Seat test	1.0	2	
					PN 1.6	Body test	2.4	5	
						Seat test	1.6	2	

Table 2 (*Continued*)

Sl No. (1)	IS No., Title (2)	Classification/ Designation (3)	Types (4)	Nominal Sizes (mm) (5)	Hydrostatic Test Pressure and Duration (6)	Remarks (7)
vi)	IS 3042 : 1965 Specification for single faced sluice gates (200 to 1200 mm sizes)	Class 1 — Suitable for a maximum seating unbalanced head of 6 m of water. Class 2 — Suitable for a maximum seating unbalanced head of 15 m of water	Rising or Non-rising spindle type	*Shape* — *Size* Circular — 200 to 1200 mm Square — 200 to 1200 mm Rectangular — 300 x 375 to 1200 x 1050	—	—
vii)	IS 5312 (Part 1) : 1984 Specification for swing check type reflux (non-return) valves for water works purposes, Part 1 Single door pattern	Designated by nominal pressure, PN (Maximum permissible working pressure in MPa). The nominal pressure for various sizes shall be : *Size of Valve, mm* — *Nominal Pressure, MPa* 50 to 125 — 1.6 150 to 300 — 1.0 350 to 600 — 0.6	Flanged type	50, 65, 80, 100, 125, 150, 200, 250, 300, 350, 400, 450, 500 and 600 mm (*see* Sl No. 2 Col. 5 for definition of nominal size)	PN Rating — Test — Test Pressure (Gauge) (MPa) — Test Duration (minutes) PN 1.6 — Body test — 2.4 — 5 Seat test — 1.6 — 2 PN 1.0 — Body test — 1.5 — 5 Seat test — 1.0 — 2 PN 0.6 — Body test — 0.9 — 5 Seat test — 0.6 — 2	—
viii)	IS 5312 (Part 2) : 1986 Specification for swing check type reflux (non-return) valves for water works purposes Part 2 Multi-door Pattern	Designated by nominal pressure, PN (Maximum permissible gauge working pressure in MPa). It shall have the following rating : PN 0.6, PN 1.	Flanged type	400, 450, 500, 600, 700, 750, 800, 900, 1000 and 1200 mm. The nominal size is the nominal bore of water way.	PN Rating — Test — Test Pressure (Gauge) *Min* (MPa) — Test Duration *Min* (minutes) PN 0.6 — Body test — 0.9 — 2 Seat test — 0.6 — 2 PN 1 — Body test — 1.5 — 2 Seat test — 1.0 — 2	—
ix)	IS 9338 : 1984 Specification for cast iron screw-down stop valves and stop and check valves for water works purposes	Designated by nominal pressure, PN (Maximum permissible gauge working pressure in MPa) for the sizes indicated as follows : *Nominal Pressure* MPa — *Nominal Size* mm 1.0 — 200 to 300 1.6 — upto and including 150	a) Globe stop valve b) Angle stop valve c) Oblique stop valve d) Globe stop and check valve, and e) Angle stop and check valve All flanged.	15, 20, 25, 32, 40, 50, 65, 80, 100, 125, 150, 200, 250 and 300 mm (*see* Sl No. 2 Col. 5 for definition of nominal size)	PN Rating — Test — Test Pressure (Gauge) *Min* (MPa) — Test Duration *Min* (minutes) PN 1.6 — Body test — 2.4 — 5 Seat test — 1.6 — 2 Back Seat test (where specified) — 2.4 — 5 PN 1.0 — Body test — 1.5 — 5 Seat test — 1.0 — 2 Back Seat test (where specified) — 1.5 — 5	—

Table 2 (*Concluded*)

Sl No.	IS No., Title	Classification/ Designation	Types	Nominal Sizes (mm)	Hydrostatic Test Pressure and Duration	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
x)	IS 9739 : 1981 Specification for pressure reducing valves for domestic water supply purposes	—	Self contained, direct acting, single seat, diaphram type	15 mm (1/2), 20 mm (3/4), 25 mm (1), 32 mm ($1\frac{1}{4}$), 40 mm ($1\frac{1}{2}$), and 50 mm (2). The figures given in brackets refer to sizes and designations of threaded end as per IS 554 : 1975.	When subjected to hydrostatic pressure of 1.7225 MPa at its inlet and an equal back pressure on reduced pressure side, there shall be no leakage or distortion of parts that will affect performance of valves.	
xi)	IS 9763 : 1981 Specification for plastic bib taps and stop valves (rising spindle) for cold water purposes	—	—	15 mm (1/2) and 20 mm (3/4) The sizes within brackets refer to the size and designation of the threaded ends as per IS 2643 (Part 1) : 1975. (*see* Sl No. 3, Col. 5 for definition of nominal size).	Tested complete with its components under an internal hydraulic pressure of 2MPa for a duration of 5 minutes, *Min.*	
xii)	IS 13114 : 1991 Forged brass gate, globe and check valves for water works purposes – Specification	—	a) Gate valves — Shall be of inside screw type, having screwed-in bonnet with non-rising stem, integral seats and solid wedge type in which the gate shall be one piece and solid except for the hole to accommodate the stem. b) Globe valves — shall be of inside screw type having screwed-in bonnet with rising stem and straight type, having integral seat in the body. c) Check valve — Shall be of one of the following types having screwed-in covers and integral seats in the body : i) Swing type — For use with the axis of the body end ports, horizontal or vertical (swing check valves can only be used in vertical lines when the flow is in upward direction) ii) Lift type — With disc or ball check having any of the following body designs with screwed-in covers and integral seat : — Straight (or horizontal) — Vertical	8(1/4), 10(3/8), 15(1/2), 20(3/4), 25(1), 32 ($1\frac{1}{4}$), 40 ($1\frac{1}{2}$), and 50(2) mm The nominal sizes shown in parenthesis refer to the size of screw threads according to IS 554 : 1985	All valves shall be tested for body, seat and back seat tests as given below : 1) The hydrastatic test pressure shall be determined from the following relationships : a) Shell Test — 1.5 × maximum working pressure of 2 MPa b) Seat and Back seat Test — 1.1 × maximum working pressure of 2 MPa. Seats of check valves shall also be tested to one fourth of maximum working pressure of 2 MPa. 2) Test duration for shell, seat and back seat tests — 15 seconds.	

CHAPTER 5 INSTALLATION OF PIPE-LINE

1 GENERAL

Laying of pipe-lines are generally governed by the regulations laid down by the local authorities. Authority may be an individual, an official, a board, a department or an agency established and authorised by the Union or State Government or any statutory body created by law, which undertakes to administer and enforce the regulations. These regulations are intended to ensure proper laying of pipes, giving due consideration to safety of surroundings and workers engaged in pipe laying.

The pipes have to be properly handled, bedded and back-filled to fulfill the desired design and service requirements. Even a good pipe manufactured as per the specification may be damaged by improper handling or bedding or back-filling. As various factors, such as the size of the pipe and nature of soil and surroundings influence pipe laying, it is not possible to lay down any rigid rules. Each case will have to be dealt with in different ways. Hence the procedures given here may be taken as guidelines only. Common procedure for trenching and back-filling for all types of pipes is given in 2.3.2 and 2.4. Any change in the procedure or special precautions with respect to each type of pipe are discussed separately.

2 PROCEDURES COMMON FOR ALL VARIETIES OF PIPES

SELECTION OF ROUTE

2.1 General

The selection of a suitable route for a pipe-line has an important bearing on the capital cost and operating costs. A pipe-line route is selected from topographical and cadastral plans, on-site inspections, and any other data avilable on the terrain, obstacles and local services. In selecting a route the costs and practicability have to be considered. Care should be taken to ensure that the ground profile is below the hydraulic grade line. (Low flow conditions should be considered as well as peak rates, as the hydraulic gradient is flattest for low flows). If there were a peak above the ground line between the input and discharge heads, obviously pumps would have to be designed to pump over this peak. Peaks may also be points of possible water column seperation which result in water hammer pressures. On the other hand the general level of the pipe-line route should be kept as near to the hydraulic grade line as possible to minimize pressures and consequently pipe costs. The pipe-line should be laid along the straightest route possible. Road crossings should be done at a right angle to the road whenever possible.

2.1.1 For cross country terrain before carrying out final field survey, the pipe alignment shall be marked on Survey of India maps or cadastral plans whichever is available and reconnaisance should be undertaken along the pipe route selected. Any change called for should be made before the final survey is undertaken.

2.1.2 *Final Field Survey Plans*

Field surveys for strip width representing about 500m along the proposed alignments should be carried out. Any vertical section or profile along the pipe-line route should be shown to a scale appropriate to the variations in ground elevation. Special crossings which require permission from authority should be detailed on separate drawings and cross referenced to the appropriate strip plan; the scale should be between 1 : 100 and 1 : 125 depending on the complexity of the work. In built up areas, consideration should be given to the use of plans of 1 : 1250 scale. In urban areas, trail trenches at suitable intervals will be necessary to locate the utilities which may affect the laying of pipes.

2.2 Clearing the Site

Preliminary work required to be done before pipe laying is started, includes pegging out, clearing and disposal of all shrub, grass, large and small bushes, trees, hedges, fences, gates, portions of old masonary and debris from the route.

Where trees have been felled, the resulting timber shall be stacked properly and disposed off as directed by the authority. Tree roots within a distance of about half metre from the side of the pipe-line shall be removed or killed.

All other serviceable materials, such as wood work, bricks and masonry, recovered during the operation of clearing the site shall be separately stacked and disposed off as directed by the authority.

2.3 Formation

Before pipe-line is laid, proper formation shall be prepared. For underground pipe-line, suitable trenches should be excavated, pipe-line above ground may be laid in cutting or on enbankments or be supported by pillars as the case may be.

2.3.1 *Excavation and Preparation of Trenches for Laying underground Pipe-line*

The trench shall be so dug that the pipe may be laid to the required alignment and at required depth. When the pipe-line is under a roadway, a minimum cover as given in Table 1 is recommended, but it may be modified to suit local conditions by taking necessary precautions. In tropics an earth cover of at least 0.8 m should be provided in order to protect pipes against great variation of temperature, root growth into flexible joints and against falling trees. When pipes are laid with more than 1.5 m cover a special investigation is called for to ensure that the pipes are strong enough to stand the earth pressure. If they are not, the remedy is to bed or fully surround the pipe-line with concrete. The trench shall be shored, wherever necessary, and kept dry so that the workman may work therein safely, and efficiently. The discharge of the trench dewatering pumps shall be conveyed either to drainage channels or to natural drains, and shall not be allowed to be spread in the vicinity of the work-site.

2.3.2 *Trenching*

Trenching includes all excavation which is carried out by hand or by machine. The width of the trench shall be kept to a minimum consistent with the working space required. At the bottom between the faces, it shall be such as to provide not less than a minimum clearance on either side of the pipe in accordance with Table 1. Each case should, however, be considered on its merits, having regard to the safety of the trench the method of laying and jointing the pipe and the need to avoid damage to pipe coating. The bottom of the trench shall be properly trimmed to permit even bedding of the pipe-line. For pipes larger than 1 200 mm diameter in earth and murum the curvature of the bottom of the trench should match the curvature of the pipe as far as possible, subtending an angle of about 120° at the centre of the pipe as shown in Fig. 1A. Where rock or boulders are encountered, the trench shall be trimmed to a depth of at least 100 mm below the level at which the bottom of the barrel of the pipe is to be laid and filled to a like depth with lean cement concrete or with non-compressible material like sand of adequate depth to give the curved seating, as shown in Fig. 1B and Fig. 1C.

For pipes with diameter less than 1200 mm the bed of the trench shall be excavated to the pipe grades so that uniform support is assured for the full length of the pipe (*see* Fig. 2)

For steel pipes when welding is to be carried out with the pipe in the trench, additional excavation of not more than 600 mm in depth and 900 mm in length should be provided all round the pipe at the position of the joints for facilities of welding.

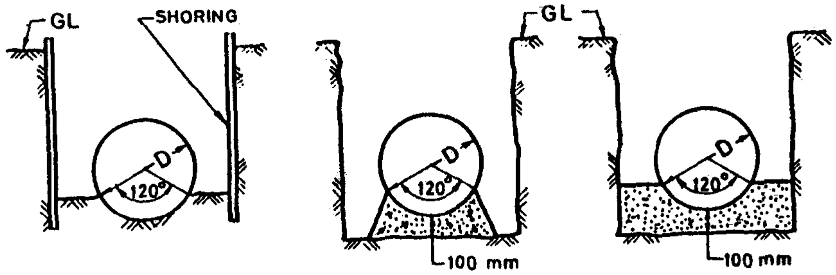
2.3.3 *Special Foundations in Poor Soils*

Where the bottom of the trench at subgrade is found to consist of material which is unstable to such a degree that, in the opinion of the authority, it cannot be removed and replaced with an approved material thoroughly compacted in place to support

Table 1 Minimum Cover Below Roadway and Minimum Side Clearance for Pipes
(*Clauses* 2.3.1 *and* 2.3.2)

Sl No.	Type of Pipe	Minimum Cover Below Roadway	Minimum Clearance on Either Side of Pipes
(1)	(2)	(3)	(4)
1)	Cast iron pipes	1 000 mm	200 mm
2)	Ductile iron pipes	900 mm	200 mm
3)	Steel pipes	1 200 mm	200 mm
4)	Concrete and prestressed concrete pipes	1)	150 mm
5)	Asbestos cement pipes	750 mm (Below footpaths) 900 mm (Roads with heavy traffic) 1 250 mm (Roads with very heavy traffic)	300 mm
6)	Plastic pipes	1 000 mm	200 mm

1) Minimum depth of cover not specified as impact factor can be increased suitably while designing the pipe in case depth of cover is less than 900 mm.

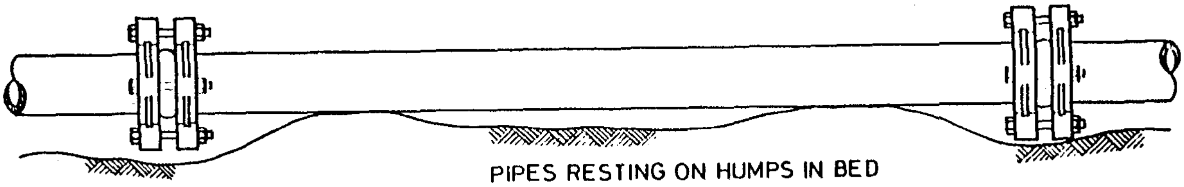


1A TRENCH IN EARTH OR MURUM

1B TRENCH IN HARD ROCK WITH CEMENT CONCRETE BEDDING

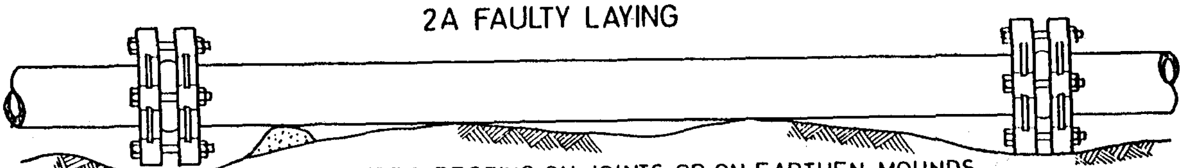
1C TRENCH IN HARD ROCK WITH SAND BEDDING

FIG. 1 TRENCHING FOR PIPES



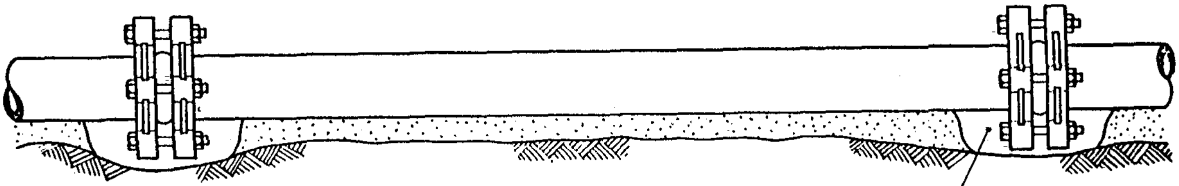
PIPES RESTING ON HUMPS IN BED

2A FAULTY LAYING



PIPES RESTING ON JOINTS OR ON EARTHEN MOUNDS

2B FAULTY LAYING



PIPES RESTING ON MADE UP BED FOR EVEN BEDDING OF PIPES

2C CORRECT LAYING

FIG. 2 LAYING OF PIPES IN TRENCHES

the pipe properly, a suitable foundation for the pipe, consisting of piling (timber or other materials) in accordance with plans prepared by the authority, shall be constructed.

2.3.4 *Rock Excavation*

Rock is an unyielding natural foundation material; includes igneous material and consolidated or cemented sedimentary mineral matter in extensive undisturbed beds or strata.

2.3.5 *Blasting*

Blasting for excavation shall be permitted only after securing the approval of the authority and only when proper precautions are taken for the protection of persons and property. The hours of blasting shall be fixed by the authority. The procedure of blasting shall conform to the requirements of local controlling authority (reference may also be made to IS 408 : 1986).

2.3.6 *Braced and Sheeted Trenches*

Open cut trenches shall be sheeted and braced as required by any governing state laws and municipal regulations and as may be necessary to protect life, property or the work. When close sheeting is required, it shall be so driven as to prevent adjacent soil from entering the trench either below or through such sheeting.

The authority shall have the right to order the sheeting to be driven to the full depth of the trench or to such additional depths as may be required for protection of the work. Where the soil in the lower limits of a trench has the necessary stability, the authority at its discretion may permit stopping of the driving of sheeting at some designated elevation above the trench bottom.

2.3.7 Sheeting and bracing which have been ordered to be left in place should be removed for a distance of 0.9 m below the established street level or the existing surface of the street, whichever is lower. Trench bracing, except that which should be left in place, may be removed when the backfilling has reached the respective levels of such bracing. Sheeting, except that which has been left in place may be removed after the backfilling has been completed or has been brought up to such an elevation as to permit its safe removal. Sheeting and bracing may be removed before filling the trench, but only in such a manner as will ensure adequate protection of the completed work and adjacent structures.

2.3.8 *Care of Surface Material for Re-use*

All surface materials which, in the opinion of the authority, are suitable for re-use in restoring the surface shall be kept separate from the general excavation material as directed by the authority.

2.3.9 *Stacking Excavated Material*

All excavated material shall be stacked in such a manner that it does not endanger the work and avoids obstructing footpaths and roads. Hydrants under pressure, surface boxes, fire or other utility controls shall be left unobstructed and accessible until the work is completed. Gutters shall be kept clear or other satsifactory provisions made for street drainage and natural water-courses shall not be obstructed.

2.3.10 *Barricades Guards and Safety Provisions*

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, torches, red lanterns and guards, as required, shall be placed and maintained during the progress of the construction work and until it is safe for traffic to use the roadway. All materials, piles, equipment and pipes which may serve as obstructions to traffic shall be enclosed by fences or barricades and shall be protected by proper lights when the visibility is poor. The rules and regulations of the local authorities regarding safety provisions shall be observed.

2.3.11 *Maintenance of Traffic and Closing Streets*

The work shall be carried in such a manner that it causes the least interruption to traffic, and the street may be closed in such a manner that it causes the least interruption to the traffic. Where it is necessary for traffic to cross open trenches, suitable bridges shall be provided.

Suitable signs indicating that a street is closed shall be placed and necessary detour signs for the proper maintenance of traffic shall be provided.

2.3.12 *Structure Protection*

Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of the work shall be furnished under the direction of the authority. The structures which may have been disturbed shall be restored upon completion of the work.

2.3.13 *Protection of Property*

Trees, shrubbery fences, poles and all other property shall be protected unless their removal is shown on the drawings or authorized by the authority. When it is necessary to cut roots and tree branches; such cutting shall be done under the supervision and direction of the authority.

2.3.14 *Avoidance of the Existing Service*

As far as possible, the pipe-line shall be laid below existing services, such as gas pipes, cables, cable ducts and drains but not below sewers, which are usually laid at great depth; if it is unavoidable pipeline should be suitably protected. A minimum clearance of 150 mm shall be provided between the pipeline and such other services. Where thrust or auger boring is used for laying pipe-line across roads, railways or other utilities, larger clearance as required by the authority shall be provided. Adequate arrangements shall be made to protect and support the other services during laying operations. The pipeline shall be so laid as not to obstruct access to the other services for inspection, repair and replacement. When such utilities are met with during excavation, the authority concerned shall be intimated and arrangements made to support the utilities in consultation with them.

2.4 Back Filling

For the purpose of back-filling, the depth of the trench shall be considered as divided into the following three zones from the bottom of the trench to its top:

Zone A	From the bottom of the trench to the level of the centre line of the pipe,
Zone B	From the level of the centre line of the pipe to a level 300 mm above the top of the pipe, and
Zone C	From a level 300 mm above the top of the pipe to the top of the trench.

2.4.1 *Back-Fill Material*

All back-fill material shall be free from cinders, ashes, slag, refuse, rubbish, vegetable or organic material, lumpy or frozen material, boulders, rocks or stone or other material which in the opinion of the authority, is unsuitable or deleterious. However, material containing stones up to 200 mm as their greatest dimension may be used in Zone C unless specified otherwise herein.

2.4.1.1 *Back-fill sand*

Sand used for back-fill shall be a natural sand complying with **2.4.1** graded from fine to coarse. The total weight of loam and clay in it shall not exceed 10 percent. All material shall pass through a sieve of aperture size 2.0 mm [*see* IS 2405 (Part 2) : 1980] and not more than 5 percent shall remain on IS Sieve of aperture size 0.63 mm.

2.4.1.2 *Back-fill gravel*

Gravel used for back-fill shall be natural gravel, complying with **2.4.1** and having durable particles graded from fine to coarse in a reasonably uniform combination with no boulders or stones larger than 50 mm in size. It shall not contain excessive amount of loam and clay and not more than 15 percent shall remain on a sieve of aperture size 75 micron.

2.4.2 *Back-Filling in Freezing Weather*

Back-filling shall not be done in freezing weather except by permission of the authority, and it shall not be made with frozen material. No fill shall be made where the material already in the trench is frozen.

2.4.3 Back-filling in Zone A shall be done by hand with sand, fine gravel or other approved material placed in layers of 150 mm and compacted by tamping. The back-filling material shall be deposited in the trench for its full width on each side of the pipe, fittings and appurtenances simultaneously.

2.4.4 Back-filling in Zone B shall be done by hand or approved mechanical methods in layers of 150 mm, special care being taken to avoid injuring or moving the pipe. The type of back-fill material to be used and the method of placing and consolidating shall be prescribed by the authority to suit individual locations.

2.4.5 Back-filling in Zone C shall be done by hand or approved mechanical methods. The types of back-fill material and method of filling shall be as prescribed by the authority.

2.4.6 *Back-Fill Under Permanent Pavement*

Where the excavation is made through permanent pavements, curbs, paved footpaths, or where such structures are undercut by the excavation, the entire backfill to the subgrade of the structures shall be made with sand in accordance with **2.4.1.1**. Paved footpaths and pavements consisting of broken stone, gravel, slag or cinders shall not be considered as being of a permanent construction. Method of placement and consolidating the backfill material shall be prescribed by the authority.

2.4.7 *Back-Fill with Excavated Material*

The excavated material may be used for back-fill in the following cases, provided it complies with **2.4.1**:

a) In Zone C, in cases where settlement is unimportant and when shown on the drawings or specified, the back-fill shall be neatly rounded over the trench to a sufficient height to allow for settlement to the required level.

b) In any zone when the type of back-fill material is not indicated or specified provided that such material consists of loam, clay, sand, fine gravel or other materials which are suitable for backfilling in the opinion of the authority.

2.4.8 *Concrete Slabs Over Pipes*

When pipes are laid under roads and pavements subjected to heavy traffic loads, the trenches may be covered with reinforced concrete slabs of suitable dimensions.

2.5 Peparation of Formation for Pipe-line Above Ground

Formation should be prepared by cutting high grounds and filling in low areas. Care shall be taken while fixing the alignment and gradient of the pipeline, to balance the cutting and filling quantities, as far as possible, with minimum of load. Care should also be taken to ensure that the pipe rests fully either on cutting or on bank.

2.5.1 *Cutting High Grounds*

Excavation for the formation in cutting should be done in such a manner as to obtain sufficient width at the bottom to accommodate the pipe-line, its supports, a service passage and side drains. The sides of the cutting should generally have the following slopes:

a) Earth *murum* and boulders	1 : 1
b) Hard *murum* and soft rocks	$^1/_2$: 1
c) Hard rock	$^1/_4$: 1

All excavated material shall be the property of the authority and shall be stacked or disposed off as directed under **2.3.3** above. Typical sections in cuttings are shown in Fig. 3 and 4.

2.5.2 *Peparation of Embankment*

Material used for embankment shall be spread in horizontal layers not more than 300 mm thick. Each layer shall be compacted by watering, ramming and rolling before the next layer is laid. Mechanical compaction is recommended. The compaction obtained shall not be less than 90 percent of the proctor density [*see* IS 2720 (Part 7) 1980]. Any wash-outs during rains shall be replaced with suitable material. The embankment shall be finished to the correct dimensions and gradient prescribed by

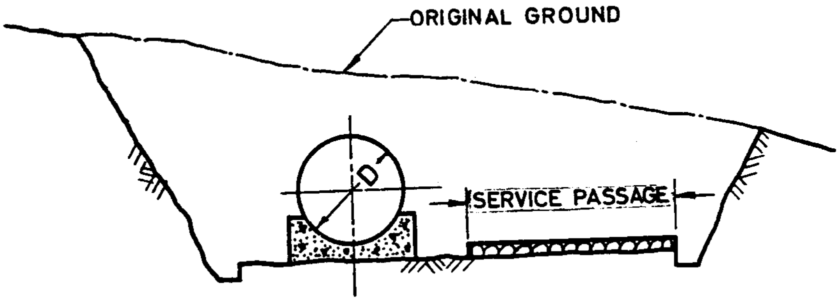


FIG. 3 SECTION IN CUTTING

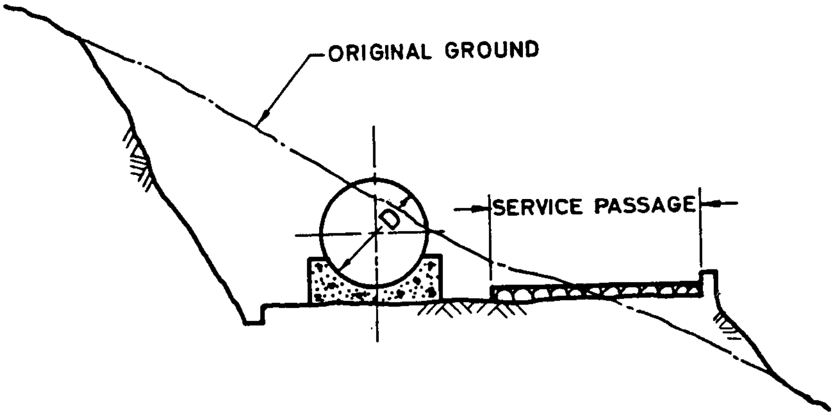


FIG. 4 SECTION IN PARTLY CUTTING AND EMBANKMENT

the authority. If banking is to be done on the sloping ground or on embankment, it shall be cut in steps of not less than 300 mm deep and 450 mm wide to give a proper bond. Side slopes of the embankment shall be steeper than 1 horizontal to 1 vertical.

The slopes of embankment should be protected by pitching or any other method, if so required by the authority.

2.5.3 *Width of Embankment*

The width of the embankment at top shall be such as to accommodate the pipe-line and the service passage. Typical section of the bank is shown in Fig. 5.

2.5.4 *Materials for Embankment*

Materials used for embankment shall be such that it does not harm the pipe-line. It shall not swell when moisture laden or shrink and crack when dry and shall have self-draining properties. Mud, clay, slush and decaying vegetable matter shall not be used. The material shall also be free from cinders, ashes, refuse, rubbish, organic material, frozen material or material which in the opinion of the authority is unsuitable or deleterious. All lumps and clods shall be broken to allow uniform subsidence of the earth work throughout the embankment.

2.5.5 *Stability of Embankment*

Emabnakment shall rest on good foundation which shall be capable of taking load of the earth fill, the pipe-line, service road, etc. When embankment is laid on soft ground, such as marshy clay or marine clay, such soft foundation shall be stabilized by providing sand piles or rubble piles. In the alternative, RCC or wooden piles should be driven to transfer load to harder substrata.

2.6 Road, Rail and River Crossing

The mode of laying the pipe-line crossing road, railway or a river shall be determined so as to satisfy the requirements of the authority concerned.

Where the pipes run beneath tram tracks or are located in areas where similar vibratory effects are likely, care should be taken to avoid any direct transmission of the vibrations to the pipes itself. Ample cover with soft well-packed filling is essential.

2.7 Conditions Unsuitable for Laying of Pipe

No pipe shall be laid in or when, in the opinion of the authority, trench conditions are unsuitable.

2.8 Casing Pipes

When the pipes run beneath the heavy loads, suitable size of casing pipes/culverts may be provided to protect the carrier pipe.

2.9 Clearance

When crossing existing pipe-lines or other structures, alignment and grade shall be adjusted as necessary, with the approval of the authority to provide clearance as required by state or local regulations or as deemed necessary by authority to prevent future damage or contamination of either structure.

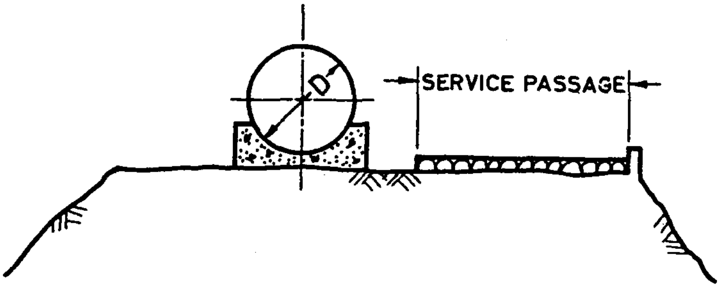


FIG 5 SECTION IN EMBANKMENT

2.10 Appurtenances

The spacing of the isolating sluice valves along a pipe-line depends upon the type of terrain through which the pipe-line passes and the operational flexibility required. Valves may be positioned as follows :

a) At the beginning and at the end of the pipe-line;

b) To facilitate hydraulic testing of sections or the pipe-line;

c) For long pipe-lines, isolating valves should be provided at intervals not exceeding 6 km; and

d) On either side of a major crossing.

Valves may be located either above ground or below ground, but should be easily accessible.

2.10.1 Control valves should be provided on all branches. Similarly, air valves at all humps and scour valves at all dips are necessary. For inspection purposes, man-holes may be provided on either side of isolating valve and at other suitable places.

2.10.2 Protective devices, such as relief valves, surge or break pressure stations, may be provided to ensure that the internal pressure at any point in the pipe-line does not exceed the design pressure.

2.10.3 Pressure indicating and flow recording instruments and burst alarms should also be provided at suitable places.

2.11 Removal, Restoration and Maintenance of Paved Footpaths, After Laying of Pipe

2.11.1 *Allowable Removal of Pavement*

Pavement and road surfaces may be removed as a part of the trench excavation, and the amount removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the installation of gate valves, specials, man-holes or other structures. The width of pavement removed along the normal trench for the installation of the pipe shall not exceed the width of the trench specified by more than 150 mm on each side of the trench. The width and lengths of the area of pavement removed for the installation of gate valve, specials, man-holes or other structures shall not exceed the maximum linear dimensions of such structures by more than 150 mm on each side. Wherever, in the opinion of the authority, existing conditions make it necessary or advisable to remove additional pavement, it shall be removed as directed by the authority.

2.11.2 *Replacement of Pavements and Structures*

All pavements, paved foothpaths, curbing, gutters, shrubbery, fences, poles, sods or other property and surface structures removed or disturbed as a part of the work shall be restored to a condition equal to that before the work began, furnishing all labour and materials incidental thereto. In restoring the pavement, sound granite blocks, sound brick or asphalt paving blocks may be re-used. No permanent pavement shall be restored unless and until, in the opinion of the authority, the condition of the backfill is such as to properly support the pavement.

2.11.3 *Cleaning-up*

All surplus water main materials and all tools and temporary structures shall be removed from the site as directed by the authority. All dirt, rubbish and excess earth from the excavation shall be hauled to a dump and the construction site left clean to the satisfaction of the authority.

3 LAYING AND JOINTING OF CAST IRON PIPE

3.1 Lowering of pipes and fittings

Proper implements, tools and facilities satisfactory to the Authority shall be provided and used for the safe and convenient execution of the work. All pipes, fittings, valves and hydrants shall be carefully lowered into the trench, piece by piece, by means of a derrick, ropes or other suitable tools or equipment, in such a manner as to prevent damage to pipe materials and protective coatings and linings. Under no circumstances shall pipe materials be dropped or dumped into the trench. Pipes over 300 mm diameter shall be handled and lowered into trenches with the help of chain pulley blocks. Tripod supports used for this purpose shall be regularly checked to prevent all risks of accidents.

3.2 Cleaning Pipes and Fittings

All lumps, blisters and excess coating material shall be removed from the socket and spigot end of each pipe and the outside of the spigot and the inside of the socket shall be wire-brushed and wiped clean and dry and free from oil and grease before the pipe is laid.

3.3 Laying Pipe

Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the line. If the pipe-laying team cannot put the pipe into the trench and in place without getting earth into it, the authority may require that before lowering the pipe into the trench, a heavy, tightly woven canvas bag of suitable size shall be placed over each end and left there until the connection is to be made to the adjacent pipe. During laying operations, no debris, tools, clothing or other materials shall be placed in the pipe.

After placing a length of pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to gradient. The pipe shall be secured in place with approved backfill material tamped on either side except at the socket. Pipe and fittings which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipe and fittings of proper dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the joint space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the authority.

Joints of pipe in the trench which cannot be poured shall be caulked with jointing materials to make them as watertight as possible.

3.4 Number of Pipes Laid Before Jointing

Wherever the jointing material specified is cement, six or more lengths of pipe shall be laid in place ahead of each joint before such a joint is finished.

3.5 Cutting of Pipe

The cutting of pipe for inserting valves, fittings or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe or cement lining so as to leave a smooth end at right angles to the axis of the pipe. For this purpose use of a pipe cutting machine is recommended. When pipe cutting machine is not available for cutting pipes of large diameters, the electric-arc cutting method may be permitted using a carbon or steel rod. Only qualified and experienced workmen shall be employed on this work. When the pipe cutting machine is not available and the site conditions do not permit pipe cutting by machines, the pipe can be cut using chisels. The flame cutting of pipe by means of an oxyacetylene torch shall not be allowed.

3.6 Direction of Laying of Socket End

On level ground, the socket ends should face the upstream. When the line runs uphill the socket ends should face the upgrade.

3.7 Permissible Deflection at Socket and Spigot Joints

Where necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted, deflection at joint shall not exceed the following:

Lead joints	$2^1/_2$°
Rubber joints	
For nominal bore 80 to 300 mm	5°
For nominal bore 350 to 400 mm	4°
For nominal bore 450 to 750 mm	3°

3.8 Usage of Anchor and Thrust Blocks in Pipelines

3.8.1 *General*

High pressure mains need anchorages at dead ends and bends, as appreciable thrust occur which tend to cause 'draw' and even blow out of joints. Where the thrust is appreciable, concrete blocks should be installed at all points where movement may occur.

3.8.2 *Hydrants*

The bowl of each hydrant shall be well braced against a sufficient area of unexcavated earth at the end of the trench with stone slab or concrete backing, or it shall be tied to the pipe with suitable metal tie rods, clamps, or restrained joints as shown or directed by the authority. Tie rods, clamps or other components of dissimilar metal shall be protected against corrosion by hand application of a bituminous coating.

3.8.3 *Pipe-lines*

Anchorages are necessary to resist the tendency of the pipes to pull apart:

a) At bends or other points of unbalanced pressure, or

b) When they are laid on steep gradients and the resistance of their joints to longitudinal (shearing) stresses is either exceeded or inadequate. They are also used to restrain or direct the expansion and contraction of rigidly joined pipes under the influence of temperature changes.

It is advisable to avoid sharp bends above 45° and in soft ground it is better not to put two bends together but to separate them by at least a length of a straight pipe. If the pressures are high enough to merit it and sleeve joints are being used, the joints on the bends and on two pipes either side of them should be fully welded inside and outside, and the trench, refilled with concrete to 150 mm above these pipes and bends. Pipes laid on steep inclines should be anchored or transversed blocks or other precautions taken to prevent slippage and measures to overcome unbalanced pressures provided.

Anchor or thrust blocks shall be designed in accordance with IS 5330 : 1984. Thrust resistant design pressure should be equal to the test pressure.

3.8.4 *Restrain Materials*

Vertical and horizontal reaction backing shall be made of concrete of grade M15 conforming to IS 456 : 1978.

3.9 Jointing of Cast Iron Pipes

3.9.1 *Jointing of Socket and Spigot Pipes*

Jointing may be done with any one of the following materials:

a) Molten lead (under dry conditions),

b) Lead wool (under wet conditions),

c) Cement, and

d) Tarred yarn (for sewers only where considered necessary).

3.9.2 *Yarning of Packing Material*

Yarning of packing material shall consist of one of the following:

a) Spun yarn,

b) Moulded or tubular natural or synthetic rubber rings,

c) Asbestos rope, or

d) Treated paper rope.

NOTE – In sewerage system the usage of natural or synthetic rubber rings may be decided by the authority taking into consideration the characteristics of effluent.

All the material mentioned in **3.9.2** shall be handled with care in order to prevent contamination and shall be dry when put into place in the joint. The material used shall be free of oil, tar or greasy substances. In cement joints, the yarning materials may be omitted if so specified.

NOTE – Spun yarn used as a jointing material shall be sterilized quality. It shall have been exposed to vapours of 40 percent formaldehyde in air-tight chamber for three hours before using it in water main.

3.9.3 *Placing of Yarning Material*

The yarning material shall be placed around the spigot of the pipe and shall be of proper dimensions to centre the spigot in the socket. When the spigot is shoved home, the yarning material shall be driven tightly against the inside base or hub of the socket with suitable yarning tools.

When a single strand of yarning material is used, it shall have an overlap at the top of not more than 50 mm. When more than a single strand is required for a joint, each strand shall be cut to sufficient length so that the ends will meet without causing overlap. The ends of the strands shall meet on opposite sides of the pipe and not on the top or at the bottom. Successive strands of yarning material shall be driven home separately.

3.9.4 *Lead Joints*

3.9.4.1 Lead for caulking purposes should conform to IS 782 : 1978.

3.9.4.2 *Quantity of lead for joints*

The quantity of lead required for different sizes of pipes are given in Table 2.

3.9.4.3 *Heating and pouring of lead*

Lead shall be heated in a melting pot kept in easy reach of the joint to be poured so that the molten metal will not be chilled in being carried from the melting pot to the joint and shall be brought to a proper temperature so that when stirred it will show a rapid change of colour. Before pouring, all scum shall be removed. Each joint shall be made with one continuous pour filling of the entire joint space with lead. Spongy or imperfectly filled joints shall be burnt/chiselled out and repoured.

Table 2 Quantity of Lead for Different Sizes of Pipes
(*Clause* 3.9.4.2)

Nominal Size of Pipe mm (1)	Lead per Joint kg (2)	Depth of Lead Joint mm (3)
80	1.8	45
100	2.2	45
125	2.6	45
150	3.4	50
200	5.0	50
250	6.1	50
300	7.2	55
350	8.4	55
400	9.5	55
450	14.0	55
500	15.0	60
600	19.0	60
700	22.0	60
750	25.0	60
800	31.5	65
900	35.0	65
1 000	41.0	65
1 100	46.0	65
1 200	52.0	70
1 500	66.5	75

NOTE — The quantities of lead given are provisional and a variation of 20 percent is permissible either way.

3.9.4.4 *Position of joint runner*

The joint runner shall fit snugly against the face of the socket and the outside of the pipe shall be dammed with clay to form a pouring lip to provide for filling the joint flush with the face and to the top of the socket.

3.9.4.5 *Procedure for caulking of socket and spigot joints*

The common form of joint is made by first caulking a spun yarn then filling the remainder of the joint space by running in molten lead, taking care that no dross enters the joint, and then thoroughly caulking the lead. The lead need not extend into the joint further than the back of the groove formed in the socket.

The spun yarn is used to centre the spigot in the socket, to prevent the flow of molten lead into the bore of the pipe, to reduce the amount of lead required to complete the joint and to make the joint watertight. Spun yarn may become infected with bacteria, which may contaminate the water and, therefore, shall be effectively disinfected before use.

Alternately, proprietary brands of sterilized spun yarn may be used. Shreded lead or lead wire or strip may be used instead of spun yarn, thus producing a solid lead joint. Lead covered yarn may also be used which does not have the disadvantages of plain yarn. Cold lead may be caulked into the joint space first followed by spun yarn, and the joint then completed with cold or molten lead.

Caulking may be done with pneumatic tools or with a hand hammer weighing not less than 2 kg. When working with lead wool, it is very important to use caulking tools of appropriate thickness to fill the joint space, and to thoroughly consolidate the material from the back to the front of the socket. Lead run joints shall be preferably finished 3 mm behind the socket face.

3.9.4.6 *Quantity of lead wool and spun yarn for joints*

The quantity of lead wool and spun yarn required for different sizes of pipes are given in Table 3. As lead wool jointing is mostly done in difficult site conditions, higher tolerances may be permitted in practice from the standards specified in Table 3.

3.9.5 *Cement joints*

3.9.5.1 Where cement joints are used for cast iron gravity sewers, cement as permitted in IS 456 : 1978 may be used.

3.9.5.2 *Procedure*

Closely twisted spun yarn gasket of such diameter as required to support the spigot of the pipe at the proper grade and make truly concentric joints, and in one piece of sufficient length to pass around the pipe and lap at the top, shall be thoroughly saturated in cement paste. This gasket shall be laid in the socket

Table 3 Quantities of Lead Wool and Spun Yarn for Different Sizes of Pipes

(*Clause* 3.9.4.6)

(Materials for Single Collar Joints)

Nominal Internal Dia mm	Lead Wool Weight kg	Spun Yarn Weight kg
(1)	(2)	(3)
80	1.30	0.17
100	1.70	0.23
150	2.41	0.34
175	2.89	0.37
200	3.37	0.57
225	3.63	0.64
250	4.11	0.74
300	4.82	0.82
350	6.04	1.17
375	6.52	1.25
400	7.00	1.33
450	9.64	1.84
500	10.86	1.99
600	12.79	2.83
750	15.68	3.52
825	17.12	3.88
900	18.80	4.25
1 200	28.44	6.01

NOTE — Under special circumstances the Engineer-in-Charge may decide the quantities of lead wool/spun yarn depending upon the site conditions.

for the lower third of the circumference of the joint and covered with cement mortar (1 cement : 1 coarse sand). The spigot of the pipe shall be thoroughly cleaned with a wet brush, inserted and carefully driven home, after which a small amount of mortar shall be inserted in the annular space around the entire circumference of the pipe and solidly rammed into the joint with a caulking tool, the mortar previously placed being driven ahead of the gasket. The remainder of the joint shall then be completely filled with mortar and bevelled off at an angle of 45 degrees with the outside of the pipe. On pipes of 450 mm in diameter or larger, the joints shall be pointed and smoothed from the inside. While making cement joints, one lead joint shall be introduced for every ten cement joints.

The inside of the pipe shall be cleaned after the mortar sets slightly by dragging a large gunny-wrapped block of wood or straw through the pipe. Care is, however, necessary to see that this block is not left in the sewer when the work is interrupted or completed.

3.9.5.3 *Time interval before filling pipe*

Pipe laid with cement joints shall not be filled with water until a lapse of twelve hours after the last joint in any valved section has been made, and pressure shall not be permitted in the pipe until all joints have aged.

3.9.6 *Flanged Joints*

Cast iron pipes may also be jointed by means of flanges.

3.9.6.1 The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber (*see* IS 638 : 1979) of thickness between 1.5 to 3 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness.

3.9.6.2 Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The practice of fully tightening the bolts one after another is highly undesirable.

3.9.6.3 Several proprietary flexible joints are available for jointing cast iron pipes and these may be used with the specific approval of the authority; however, they shall be used strictly in accordance with the manufacturer's instructions.

3.9.6.4 For branches of small diameter cast iron piping, copper-alloy screwed unions or ferrules shall be used, and for large diameters, the joints shall be made by flanged connecting pieces.

4 LAYING AND JOINTING OF DUCTILE IRON PIPES

4.1 Laying Underground

Pipes should be lowered into the trench with tackle suitable for the weight of pipes. For smaller sizes, up to 250 mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes, either a well designed set of shear legs or mobile crane should be used. When lifting gear is used, the positioning of the sling to ensure a proper balance, should be checked when the pipe is just clear of the ground. If sheathed pipes are being laid, suitable wide slings or scissor dogs should be used.

All construction debris should be cleared from the inside of the pipe either before or just after a joint is made. This is done by passing a pull-through in the pipe, or by hand, depending on the size of the pipe. When laying is not in progress, a temporary end closure should be securely fitted to the open end of the pipe-line. This may make the pipe buoyant in the event of the trench becoming flooded, in which case the pipes should be held down either by partial refilling of the trench or by temporary strutting. All persons should vacate any section of trench into which the pipe is being lowered.

4.1.1 On gradients of 1 : 15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe should be held firmly in position while the trench is backfilled over the barrel of the pipe. The backfill should be well compacted.

4.2 Laying Above Ground

The ground should be dressed to match the curvature of the pipe shell for an arch length subtending an angle of 120° at the centre of the pipes. Alternatively, the pipe-line should be laid either on saddle, roller or rocker supports as specified by authority. The pipes may be allowed to rest on ground if the soil is non-aggressive.

4.3 Supporting Pipes above Ground

The following recommendations assume that no additional bending moments above those due to the self weight of the pipe and its contents are present.

4.3.1 *With Spigot and Socket Pipes*

It is recommended that above ground installation of spigot and socket pipes be provided with one support per pipe, the supports being positioned behind the socket of each pipe.

This results in a normal distance between supports of 4 m as shown in Fig. 6A.

Pipes should be fixed to the supports with mild steel straps so that axial movement due to expansion or contraction resulting from temperature fluctuation, is taken up at individual joints in the pipe-line. In addition, joints should be assembled with the spigot end withdrawn 5 to 10 mm from the bottom of the socket to accommodate these thermal movements.

Pipes supported in this way are capable of free deflection and axial movement at the joints which accommodate small movements of the pipe supports.

The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc.

Where a pipe-line crosses a watercourse, the design and method of construction should take into account the characteristics of the watercourse. Early consultation with river authorities will assist in evaluating the effect of river characteristics (for example, nature of bed, scour levels, maximum velocities, high flood levels, seasonal variations, etc), on design and construction.

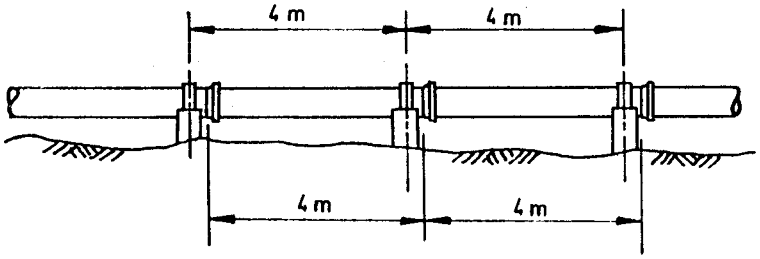
If necessary, unsupported spans between 4 and 6 m may be obtained by positioning the pipe supports relative to the pipe joints as shown in Fig. 6B.

4.3.2 *With Flanged Pipes*

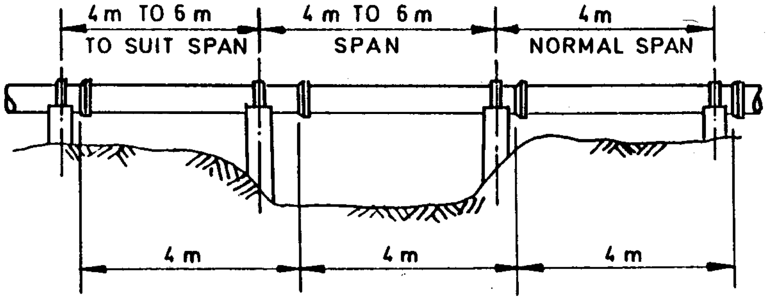
The recommended maximum unsupported span is 8 m. The supports shall be located at the centre of every second pipe as shown in Fig. 7 A

The relative positions of pipe joints and pipe supports should be as shown in Fig. 7B.

The supports of all flanged pipework spans should be stable and unyielding due to movements in the pipe-line.

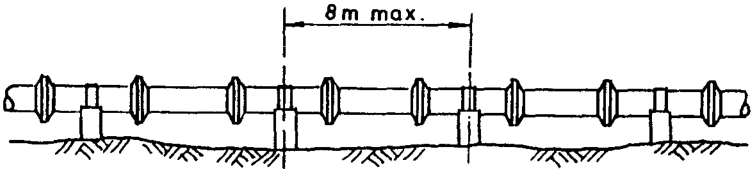


6A. PIPES OVER NORMAL GROUND

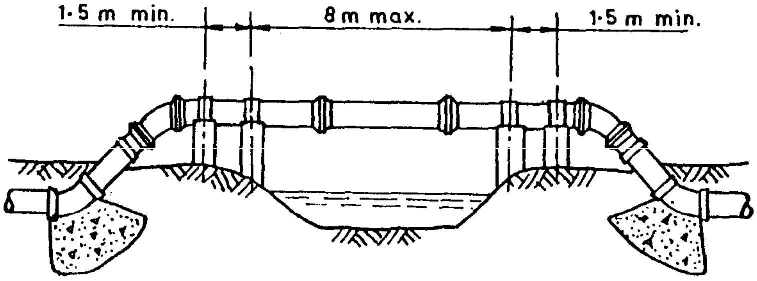


6B. PIPES CROSSING OVER WATER COURSE

FIG. 6 SPIGOT AND SOCKET PIPES LAYING ABOVE GROUND



7A. PIPES ABOVE NORMAL GROUND



7B. PIPES CROSSING WATER COURSE

FIG. 7 FLANGED PIPE LAYING ABOVE GROUND

The straps should prevent any lateral movement or lifting of the pipe-lines but not restrict expansions and constructions caused by temperature fluctuations.

4.4 Cutting of Pipes

The cutting of pipe for inserting valves, fittings, etc, shall be done in a neat and workman like manner without damage to the pipe or lining so as to leave a smooth end at right angles to the axis of the pipe. Methods of cutting ductile iron pipes are given in **4.4.1** to **4.4.3**.

4.4.1 *By Hacksaw*

Hand or power operated hacksaw should be used with blades having teeth at a pitch of 1 mm.

4.4.2 *By Manually Operated Wheel Cutter*

The type of cutting wheel used for cast iron pipes is not suitable for ductile iron pipe. Special wheels, as used for cutting steel pipes, shall be used and cut ends are trimmed with a file.

4.4.3 *By Pipe Cutting Machine*

Machines with cutter heads or abrasive wheels shall be used. Cutter head should have a front rake angle of 7° as used for steel pipes.

4.5 End Preparation of Cut Pipes for Jointing

The burr left after cutting should be trimmed off by light grindng or by filing.

4.6 Wrapping

When ductile iron pipes are to be laid in aggressive soils, the pipes should be wrapped externally with protective coatings, such as bitumen or coal tar sheathing protective tapes or by loose polyethylene sleeving, or in certain circumstances, concrete before laying. At joints, bends and valves, precautions should be taken to provide sufficient overlap of the wrapping sleeve so that no pipe-line is exposed to the aggressive soil.

4.7 Pipe-line Markers

Distinctive markers should be erected at all roads, railways, river and canal crossings, and elsewhere as required to identify the pipe-line and to indicate its position. Markers should be placed at field boundaries, preferably in such a way that they are not obscured by vegetation. At all valve installations, plates should be provided to give the same information as on the markers. Markers should not be treated with any substance likely to be harmful to livestock.

4.8 Pipe-line Anchorage

All pipe-lines having unanchored flexible joints require anchorage at changes of direction and at dead ends to resist the static thrust developed by internal pressure. Dynamic thrusts caused by flowing water act in the same direction as static thrusts. This thrust is of sufficient magnitude at high velocities to warrant safety consideration.

Anchorages to resist the thrust should be designed taking into account the maximum pressure the main is to carry in service or on test, and the safe bearing pressure of the surrounding soil.

Where possible, concrete anchor blocks should be of such a shape as to allow sufficient space for the remaking of the joints. Figure 8 shows typical anchorage using concrete thrust blocks.

Pipe-line should be securely anchored at dead ends, tees, bends, tapers and valves to resist thrust arising from internal pressure. Anchors and thrust blocks should be designed in accordance with IS 5330 : 1984. Steeply inclined pipe-lines should be secured by transverse anchors spaced as shown below:

Spacing of Transverse Anchors for Steeply Inclined Pipe-lines

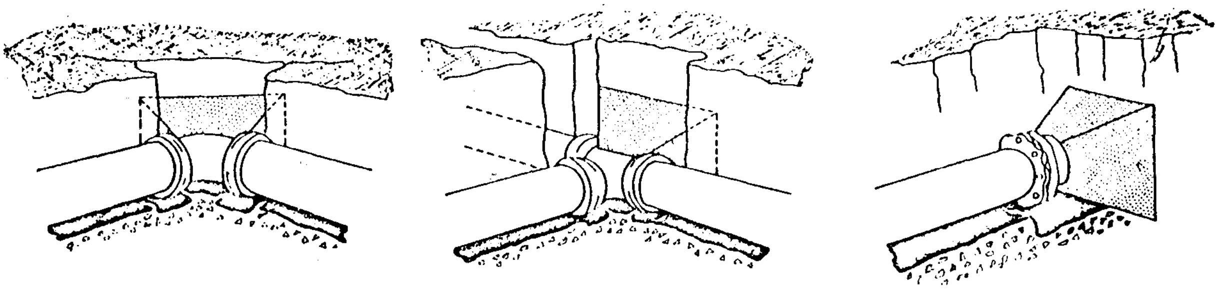
Gradient	*Spacing* m
1 in 2 and steeper	5.5
Below 1 in 2 to 1 in 4	11.0
Below 1 in 4 to 1 in 5	16.5
Below 1 in 5 to 1 in 6	22.0
Flatter than 1 in 6	Not usually required

Typical anchor blocks to resist horizontal thrust, vertical thrust and gradient thrust for buried mains are shown in Fig. 8.

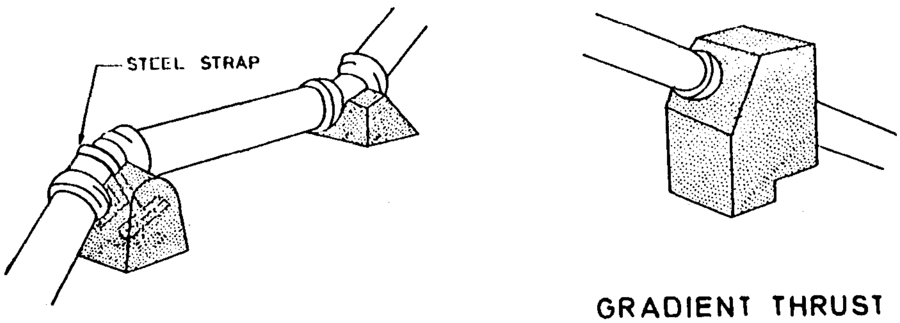
4.9 Joints and Jointing of Ductile Iron Pipes

Two main types of joints are used with ductile iron pipes and fittings:

a) Socket and spigot flexible joints:
   1) Push on joints; and
   2) Mechanical joints.
b) Rigid flanged joint.



BEND TEE DEAD END



VERTICAL THRUST BURIED MAINS

GRADIENT THRUST

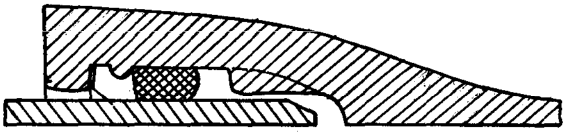
FIG. 8 TYPICAL THRUST BLOCKS

4.9.1 *Flexible Joint*

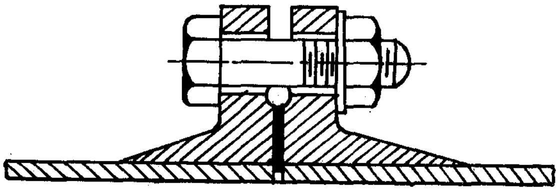
The spigot and socket flexible joint should be designed to permit angular deflection in direction and axial movement to compensate for ground movement and thermal expansion and contraction. They incorporate gasket of elastomeric materials and the joints may be of the simple push-on-type or the type where the seal is effected by the compression of a rubber gasket between a seating on the inside of the socket and the external surface of spigot. Joints of the latter type are referred to as mechanical joints. Both push-in (Fig. 9A) and mechanical joints are flexible joints. Flexible joints require to be externally anchored at all changes in direction such as at bends, etc, and at blank end to resist the thrust created by internal pressure and to prevent the withdrawal of spigots.

4.9.2 *Flanged Joint*

Flanged joints are made on pipes having a machined flange at each end of the pipe. The seal is usually effected by means of a flat rubber gasket compressed between two flanges by means of bolts which also serve to connect the pipe rigidly (*see* Fig. 9B). Gaskets of other materials, both metallic and non-metallic, are used for special applications.



9A. FLEXIBLE JOINT (PUSH IN TYPE)



9B. FLANGED JOINT

FIG. 9 TYPICAL TYPES OF JOINTS

4.9.3 *Jointing Procedure*

Procedure for jointing will vary according to the type of joint being used. Basic requirements for all types are:

a) Cleanliness of all parts,

b) Correct location of components,

c) Centralization of spigot within socket, and

d) Strict compliance with manufacturer's jointing instructions.

The inside of sockets and the outside of spigots should be cleaned and wirebrushed for a distance of 150 to 225 mm. Glands and gaskets should be wiped clean and inspected for damage. When lifting gear is used to place the pipe in the trench, it sould also be used to assist in centralizing the spigot in the socket.

Where the pipe-line is likely to be subjected to movement due to subsidence or temperature variations, the use of flexible joints is recommended. A gap should be left between the end of the spigot and the back of the socket to accommodate scuh movement.

5 LAYING AND JOINTING OF STEEL PIPES

5.1 Laying of Pipes Underground

The procedure for trenching as described in **2.3.2** shall be carefully followed. Before the pipe is lowered, the trench shall be carefully examined to determine that an even bedding is provided for the pipe-line and that the pipe may be lowered into it without damaging the coating.

5.1.1 *Lowering and Assembling of Pipes and Specials*

The procedure for lowering varies with the method adopted for coating the pipe-line. Where the coating is to be done in the trench, the pipe may be lowered in the trench on supports sufficiently high so as to facilitate out-coating. The pipe should be lowered progressively with the help of shear legs or cranes using wide belts or slings. In case of coated pipes, extra care shall be taken to preserve the coating while lowering. Slings may be removed progressively without the necessity of digging under the pipe. Where the trench is sheeted, the pipes shall be lowered into the trench by removing at a time, one or two struts only, care being taken to see that no part of the shorting is disturbed or damaged. If necessary, additional struts may be fixed during lowering. After the pipe is lowered, it shall be laid in correct line and level by use of levelling instruments, sight rails, theodolites, etc. Care shall be taken to see that the longitudinal joints of the consecutive pipes are staggered by at least 30° and should be kept in upper third of the pipe-line, if there are two longitudinal joints they should be on the sides. While assembling, the pipe faces shall be brought close enough to leave a uniform gap not exceedng 3 mm. The spiders from inside and tightening rings from outside or other suitable equipment should be used to keep the two faces in shape and position till at least one run of welding is carried out.

5.1.1.1 The pipe faces shall first be tack-welded alternately at one or more diametrically opposite pairs of points. After completing tack-welding, full welding shall be carried out in suitable runs following a sequence of welding portions of segments diametrically opposite.

5.1.2 *Backfilling*

Backfilling should closely follow the welding of joints of the pipe so that the protective coating does not get subsequently damaged. Material harmful to the pipe-line shall not be used for backfilling. Refilling shall be done in layers not exceeding 300 mm. Each layer shall be compacted by watering and ramming, care being taken to prevent damage to the pipe-line. The filling on the two sides of the pipe-line should be carried out simultaneously.

5.1.2.1 The spiders provided during assembly and welding shall be retained until the trench is refilled and compacted. Where timbers are placed under the pipe-line to aid alignment, these shall be removed before backfilling. For further precautions and use of material in backfilling, reference should be made to **2.4**.

5.2 Laying of Pipes Above Ground

5.2.1 *General*

The procedure of handling the pipes as described in **5.1** and for lowering and assembling the pipes underground as described in **5.1.1** should be followed for lifting and laying the pipes on supports or on ground. The pipe-line may be allowed to rest on ground if the soil is non-aggressive. The ground should, however, be dressed to match the curvature of the pipe shell for an arch length subtending an angle of 120° at the centre of pipes. Alternatively, the pipe-line should be laid either on saddle or roller and rocker supports as specified by the authority. Figures 10 & 11 show supports generally adopted on steel pipe-lines.

5.2.2 *Expansion Joints*

For all pipe-lines laid above ground, provision for expansion and contraction on account of temperature variation should be made either by providing expansion joints at predetermined intervals or by providing loops where leakage through expansion joints are provided, it is necessary to create restraining points on the pipe-line to ensure proper functioning of these joints. The pipe laying work should preferably start from the restrained points on either side working towards centre where the expansion joint should be fitted last. Spacing of expansion joint depends on local conditions. Provision of expansion joint at intervals of 300 m on exposed steel pipe-line is generally recommended. Expansion joints should always be provided between two fixed supports or anchorages.

5.2.3 *Anchorages*

The pipe shall be anchored by concrete anchor blocks or other means to resist unbalanced water pressures and temperature stresses. Provision should be made to anchor the main during construction and in service where floatation could occur.

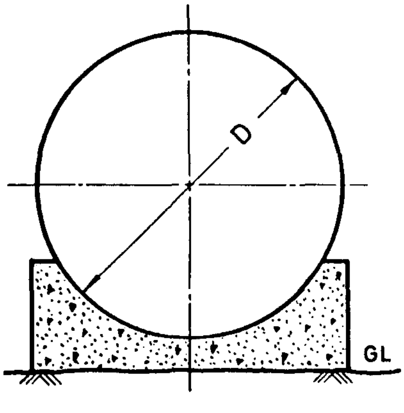


FIG. 10 SADDLE SUPPORT

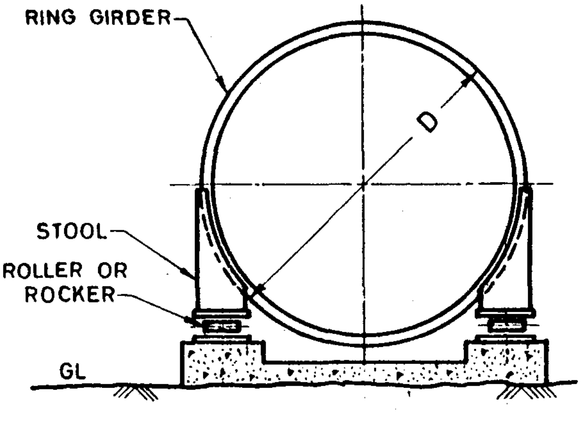


FIG. 11 ROLLER OR ROCKER SUPPORT

5.3 Jointing of Steel Pipes

5.3.0 Steel Pipes with Diameter 200 mm and Above are Joined By Welding

Before aligning, assembling and welding, the pipe faces shall be cleaned by scraping by wire brushes or any other method specified by the authority.

5.3.1 *Welding*

5.3.1.1 *General*

The welding of pipes in the field should comply with IS 816 : 1969. Electrodes used for welding should comply with IS 814 : 1991.

5.3.1.2 *Testing of welded joints*

The welded joints shall be tested in accordance with procedure laid down in IS 3600 (Part 1) : 1985. One test specimen taken from at least one field joint out of any 10 shall be subjected to test.

If the results of the tensile test do not conform to the requirements specified, retests of two additional specimen from the same section shall be made, each of which shall conform to the required specifications. In case of failure of one or two, extensive gouging (scooping out) and repairing shall be carried out as directed by the authority.

If internal pressures exceed 1.5 MPa (15 kgf/cm^2), special attention should be given to the assembly of the pipe and the first run of weld. Non-destructive testing of the completed weld may be carried out on pipe-lines by radiographic (*see* IS 4853 : 1982) or ultrasonic method (*see* IS 4260 : 1986) as agreed upon between the user and the manufacturer.

5.3.1.3 *Welding of closure gaps*

Final welding of closure gaps should be carried out within a temperature range of average air temperature ± 8°C. For buried pipe-lines final welding may best be done after intermediate pipes have been backfilled.

5.4 Blank Flanges

Blank flanges shall be used at all ends left unattended at the temporary closure of work. Blank flanges may also be necessary for commissioning a section of the pipe-line or for testing the pipe-line laid. For temporary closures, non-pressure blank flanges consisting of mild steel plates tackwelded at the pipe ends may be used. For pipes subjected to pressures, the blank flanges should be suitably designed.

5.5 Branch Connections, Specials, Etc

Complicated specials, such as 'Y' pieces, composite bends and tapers, shall be fabricated in workshops. Small branches, single piece bends, etc, may be fabricated at site, care being taken to ensure that the fabricated fittings have at least the same strength as the pipe-line to which these are to be joined.

5.6 Jointing of Pipes with Diameter Less Than 200 mm

Small diameter pipes are mainly joined by means of screw and socket joints. White lead and spun yarn are used as leak proofing material for these joints. The white lead is applied on the threaded end with spun yarn, and inserted into the socket of other pipe. The pipe is then turned and tightened.

5.7 Coatings

5.7.1 *Buried Pipes*

Buried steel pipe-lines are liable to external corrosion and should be protected by the use of suitable coatings. The selection of coatings may be influenced by economic factors, such as the required life of the pipe-line and the maintenance cost. Maximum protection against external corrosion of buried pipelines is achieved by the use of high quality coatings in conjunction with cathodic protection system.

5.7.1.1 A number of coating materials are available. The type selected and the thickness applied depend upon the degree of protection required, the electrical resistivity of the material, its porosity, its resistance to penetration of water, its resistance to microbiological attack, its stability at the pipe-line operating temperature and its mechanical strength.

5.7.1.2 Some of the common coating used are given in Table 4.

5.7.1.3 Where pipe-line is coated at the fabrication shop or at a site yard special care should be taken to ensure that the coating is not damaged during subsequent handling and transport.

5.7.1.4 Before applying the coating, it should be ensured that the pipe is clean, that is, all loose mill scale, dirt, rust, oil, grease, moisture, etc, are removed. Pipes may be cleaned by wire brushing, pickling and phosphating or by shot blasting. Where primers are necessary, they should be applied immediately after cleaning.

5.7.1.5 All coatings should be applied in accordance with manufacturer's recommendations.

Table 4 Types of Coatings and Their Uses

(*Clause* 5.7.1.2)

Sl No. (1)	Materials (2)	Remarks (3)
i)	Hot applied coal tar based coatings	Suitable for application either at the fabrication shop or at site
ii)	Hot applied bitumen based coatings	do
iii)	Hot applied tape coatings comprising fabric tapes impregnated with bitumen or coal tar	Generally used for relatively short lengths of pipes or for field application to welded joints in the coated pipes
iv)	Cold applied tape coatings, including PVC or polyethylene	Suitable for application either at fabrication shop or at site. Also for coating field welded joints in precoated type pipes and fittings
v)	Thin film protectives based on coal tar or bitumen	Generally unsuitable for high corrosive environments
vi)	Thick mastic coatings	May be used to give extra strength to the coating
vii)	Epoxy or other resinous paints	Suitable for application either at fabrication shop or at site. Requires special techniques for application
viii)	RCC gunite	Suitable for application at site. Requires special technique for application.

5.7.1.6 When coating mentioned at Sl No. (i), (ii), (iii), (v) or (vi) in Table 4 are adopted the pipe-line shall be provided with cathodic protection to prevent pin hole formation in the pipe shell on account of corrosion.

5.7.2 *Above Ground Pipe-lines*

Pipe-lines laid above ground are liable to atmospheric corrosion and should be adequately protected by painting.

5.7.2.1 *Paints*

Should be applied as specified by the authority.

5.7.2.2 Where the pipe-line is partly above ground and partly under-ground, the coating used on the buried portion should be continued well clear of the ground.

5.7.3 *Internal Coating or Lining*

Where waters to be conveyed are corrosive in nature, the pipe-line should be provided with an internal coating or lining. Such linings are usually of bitumen, coal tar, epoxy or similar resin, concrete or cement mortar. Care should be taken to see that the material used for coating is non-toxic. The lining may be applied to the pipe before or after laying. In the former case, it should be made continuous at the joints after laying. Methods of applying internal lining vary according to the size of the pipe depending upon the working space inside the pipe. In case of large diameter pipe-lines, cement mortar lining shall preferably be carried out after the pipe-line is laid in position and the backfill in the trenches is properly consolidated. This will prevent the lining from being damaged due to deformation of pipe-line, due to self weight and also due to handling of pipes during laying operation.

5.7.4 *Dry Film Thickness*

Both for internal and external painting, the thickness of the dry paint film is very important from the point of view of determining the protective life. The minimum dry film thickness of the paint system should be specified and measurements to that effect be made by using instruments like elcometer or other reliable measuring devices.

NOTE — For Further details see IS 10221 : 1982.

6 LAYING AND JOINTING OF CEMENT CONCRETE AND PRESTRESSED CONCRETE PIPES

6.1 Trench Excavation

Trench shall be of sufficient width to provide a free working space on each side of the pipe. The free working space shall be preferably not less than 150 mm on either side. For deeper excavations wider trench may be required. The trench width should be kept minimum, sufficient to allow proper tamping of the backfill. Any inadvertant increase in the actual width should be referred to the designer. If the sides of the trench are not vertical, the toes of the side slopes shall end at the top of pipe, and practically vertically sided trench shall be dug from these down to the sub grade.

6.2 Laying

Pipes should be lowered into the trench with tackle suitable for the weight of pipes, such as well designed shear slings with chain block or mobile crane. While lifting, the position of the sling should be checked when the pipe is just clear off the ground to ensure proper balance. Laying of pipes shall preferably proceed upgrade of a slope. If the pipes have rubber ring joint it is easier to force spigot into socket. In case of collar joint, the collars shall be slipped on before the next pipe is laid. Expansion joint shall be provided for buried line at maximum intervals of 100 m, but for exposed pipes, the joint intervals shall not exceed 45 m. Cast iron or steel collars and lead caulking conforming to IS 782 : 1979 shall be used for expansion joint. Where flexible rubber ring joints are used, expansion joints need not be provided. When laying is not in progress, the open end of the pipe-line should be fitted with temporary end-closure. This may make the pipe buoyant in the event of the trench becoming flooded and any movement of the pipes should be prevented either by partial refilling of the trench or by temporary strutting.

6.3 Jointing

The sections of the pipe should be jointed together in such a manner that there shall be as little unevenness as possible along the inside of the pipe. The procedure will vary according to the type of joint being used. Basic requirements for all types are:

a) cleanliness of all parts, particularly joint surface;

b) correct location of components;

c) centralization of spigot within socket;

d) provision of the correct gap between the end of the spigot and the back of the socket (for rubber ring joint) to ensure flexibility at each joint; and

e) any lubricant used shall be approved as to composition and method of application.

Details of jointing shall be as recommended by the manufacturer.

For collar joint the loose collar shall be set up over the joint so as to have an even caulking space all round. Into this caulking space shall be rammed 1 : 1.5 mixture of cement and sand for pressure pipes and 1 : 2 for non-pressure pipes just sufficiently moistened to hold together in the hand. The caulking shall be so firm that it shall be difficult to drive the point of a pen into it. The caulking shall be employed at both ends in a slope of 1 : 1. In place of cement mortar, any other suitable approved compound may be used. Every caulked joint shall be kept wet for about ten days for maturing. The section of the pipe-line laid and jointed shall be covered immediately to protect it from weather effects. A minimum cover of 100 mm is considered adequate. A polyethylene sheet shall also be used to cover the joint to prevent evaporation of water.

6.4 Joints for Concrete Pipes

6.4.1 *Types*

The joints may be mainly of two types:

a) Rigid joints, and

b) Flexible joints.

6.4.2 *Rigid Joints*

In this the water seal is effected by cement mortar or similar material which will not allow any movement between the two pipes.

6.4.2.1 *Socket and spigot joint*

The annular space between socket and spigot is filled with cement mortar (1 : 2). This joint is used for low pressure pipe-line. The details of joint are shown in Fig. 12.

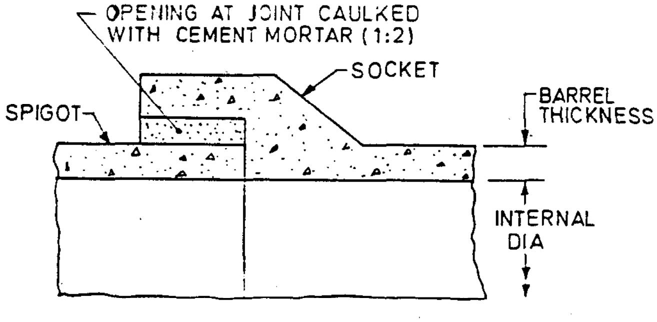


FIG. 12 SPIGOT AND SOCKET JOINT (RIGID)

6.4.2.2 *Collar Joint*

Colllars 15 to 20 cm wide cover the joint between two pipes. A slightly damp mixtures of cement and sand is rammed with caulking tool. The details are shown in Fig. 13.

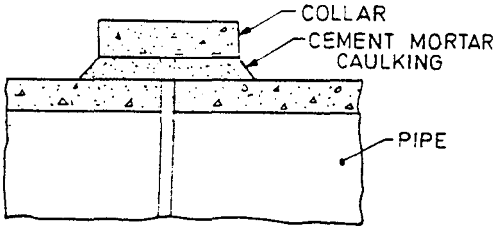


FIG. 13 COLLAR JOINT (RIGID)

6.4.2.3 *Flush joint*

a) *Internal flush joint*

This joint is generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shapcd to form a self centering joint with an internal jointing space 1.3 cm wide. The finished joint is flush with both inside and outside with the pipe wall (*see* Fig. 14). The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

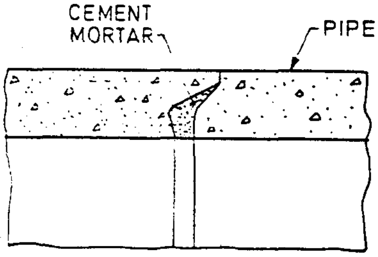


FIG. 14 INTERNAL FLUSH JOINT (RIGID)

b) *External flush Joint*

This joint is suitable for pipes which are too small for jointing from inside. Great care shall be taken in handling to ensure that the projecting ends are not damaged as no repairs can be readily effected from inside the pipe. Details of the joint are shown in Fig. 15.

6.4.3 *Flexible Joints*

The water seal is effected because of contact pressure between the sealing rubber ring (or similar material) and the pipe surface. These are mainly of two types as given below.

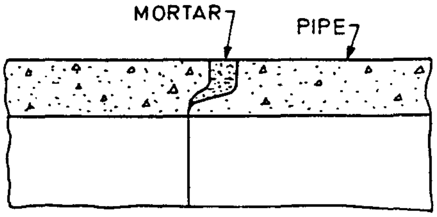


FIG. 15 EXTERNAL FLUSH JOINT (RIGID)

6.4.3.1 *Roll on joint*

A rubber ring (circular in cross-section) is placed at or near the end of the spigot and rolls along it as the spigot enters the socket. The details of the joint are shown in Fig. 16.

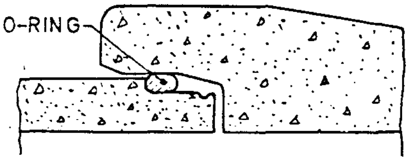


FIG. 16 ROLL ON JOINT (FLEXIBLE)

6.4.3.2 *Confined gasket*

Rubber ring of circular cross-section is held in the groove formed on the spigot. Some times, the cross-section is in the shape of lip. The lips are opened due to water pressure which ensure water seal. For assembly of this joint a lubricant has to be applied to the sliding surfaces. The lubricant washes off when the pipe is in service. The details of the joint are shown in Fig. 17.

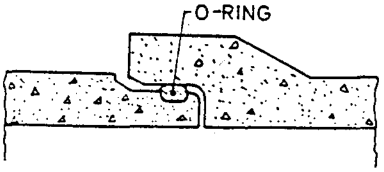


FIG. 17 CONFINED O-RING JOINT (FLEXIBLE)

6.5 Change of Direction

Small changes in direction may be made by setting adjacent pipes at a slight angle to one another. The maximum angle will vary with the type of joint used and the diameter of pipe. Maximum permissible angle shall be as recommended by the manufacturer.

6.6 Laying and Anchoring of Pipes on Gradients

Where gradient steeper than 1 in 6 is contemplated consideration should be given to the construction of suitable transverse anchor blocks spaced as shown in Table 5.

Table 5 Spacing of Transverse Anchors for Steeply Inclined Pipe-Lines
(*Clause* 6.6)

Gradient (1)	Spacing m (2)
1 : 2 or steeper	5
1 : 3 to 1 : 4	10
1 : 5 to 1 : 6	15
1 : 7 to 1 : 12	Depends on ground conditions
Flatter than 1 : 12	Not usually required

It should be noted that where very steep gradients occur the trench may act as a drain after back filling has been completed, the flow of water could disturb granular bedding material, hence, reducing the effective support for the pipes. In these circumstances alternative bedding material should be considered. If the flow of water through the bedding material is potentially substantial, clay water stops should be introduced.

In the case of gradients steeper than 1 in 15, consideration should be given to the use of suitable spacers to achieve the correct gap between the end of the spigot and the back of the socket. Pracautions should be taken to ensure that there is no movement of adjacent pipes relative to each other, immediately after the jointing operation is complete. As soon as joint assembly is complete, the last pipe laid should be firmly restrained in position until back filling over it is complete and well compacted.

7 LAYING AND JOINTING OF ASBESTOS CEMENT PIPES

7.1 Excavation

The procedure for trenching as described in **2.3.2** shall be followed. In addition to that the following precautions are to be taken as the pipes are delicate :

a) The excavation of the trench shall be so carried out that the digging of the trenches does not get far ahead of the laying operations. By doing this, the risk of falling of sides and flooding of trenches shall be avoided.

b) The walls of the trench shall be cut generally to a slope of $^1/_4 : 1$ or $^1/_2 : 1$ depending on the nature of the soil.

c) If the trench bottom is extremely hard or rocky or loose stony soil, the trench should be excavated at least 150 mm below the trench grade. Rocks, stone or other hard substances from the bottom of the trench shall be removed and the trench brought back to the required grade by filling with selected fine earth or sand (or fine murum if fine soil or sand is not available locally) and compacted so as to provide a smooth bedding for the pipe. Where excavation requires blasting operation it shall be ensured that no pipes have been stacked in the vicinity or completed pipe-line in the vicinity have already been covered before starting of blasting operations; this is necessary to prevent damage to the exposed pipes in the vicinity by falling stones as a result of blasting.

d) During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. This is necessary to prevent any damage to the completed pipe-line due to the fall of stones during re-filling of the trench.

7.2 Cutting of Pipes

7.2.1 Cutting of pipes may be necessary when pipes are to be laid in lengths shorter than the lengths supplied such as while salvaging the pipes with damaged ends or while replacing cast iron accessories like tees, bends, etc, at fixed positions in the pipeline. In such cases it may also be necessary to reduce the cut ends by rasps to suit the inner diameter of central collar. The cutting of pipes shall be done as given below.

7.2.2 A line shall be marked around the pipe with a chalk piece at the point where the cut is to be made. The line shall be so marked that the cut is truly at right angle to the longitudinal axis of the pipe. The pipe shall be rigidly held on two parallel rafters nailed to cross beams, taking care that the portion to be cut does not overhang and the cut mark is between the two rafters. The pipe shall be neatly cut at the chalk mark with carpenter's saw or hack-saw having a long blade, by slowly rotating the pipe around its longitudinal axis so as to have the uncut portion on top for cutting. Cutting of the pipe at the overhang should as far as possible be avoided, it is dangerous as an overhanging end is liable to tear off due to its weight before the cut is completed (*see* Fig. 18).

7.3 Laying of Asbestos Cement Pipes

7.3.1 The pipes shall be lowered into the trenches either by hand passing or by means of two ropes. One end of each rope shall be tied to a wooden or steel peg driven into the ground and the other end shall be held by men which when slowly released will lower the pipe into the trench.

7.3.2 The pipes shall rest continuously on the bottom of the trench. The pipes shall not rest on lumps of earth or on the joints. Four-metre long wooden templates may be used to check the level of the bed. Clearance of approximately 100 mm in depth and width equal to length of the collar plus 30 mm on both sides shall be provided at the joint which shall be refilled from side after the joint is made.

7.3.3 In unstable soils, such as soft soils and dry lumpy soils it shall be checked whether the soils can support the pipe-lines and if required suitable special foundation shall be provided.

7.3.4 Some clayey soils (for example black cotton soil) are drastically affected by extremes of saturation and dryness. In changing from totally saturated to a completely dry conditions, these soils are subjected to extraordinary shrinkage. This shrinkage is usually seen in the form of wide and deep cracks in the earth surface and may result in damages to underground structures, including pipe materials. The clay forms a tight gripping bond with the pipe, subjecting it to excessive stresses as the clay shrinks. In such areas, the engineer should establish whether the condition exists to a degree justifying special precautions. It is recommended that in such cases an envelope of a minimum 100 mm of tamped sand shall be made around the pipe-line to avoid any bonding.

7.3.5 In places where rock is encountered, cushion of fine earth or sand shall be provided for a depth of 150 mm by excavating extra depth of the trench, if necessary, and the pipes laid over the cushion. Where the gradient of the bed slopes is more than 30° it may be necessary to anchor a few pipes against their sliding downwards (*see* Fig. 19).

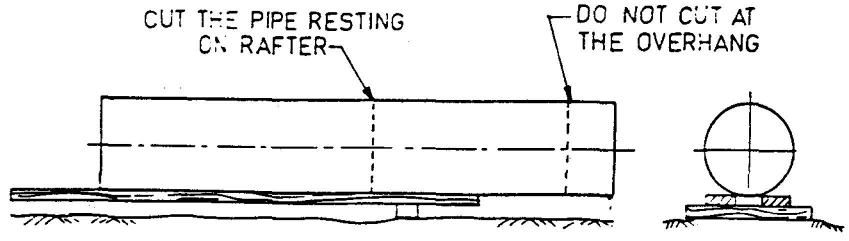


FIG. 18 CUTTING OF ASBESTOS CEMENT PRESSURE PIPE

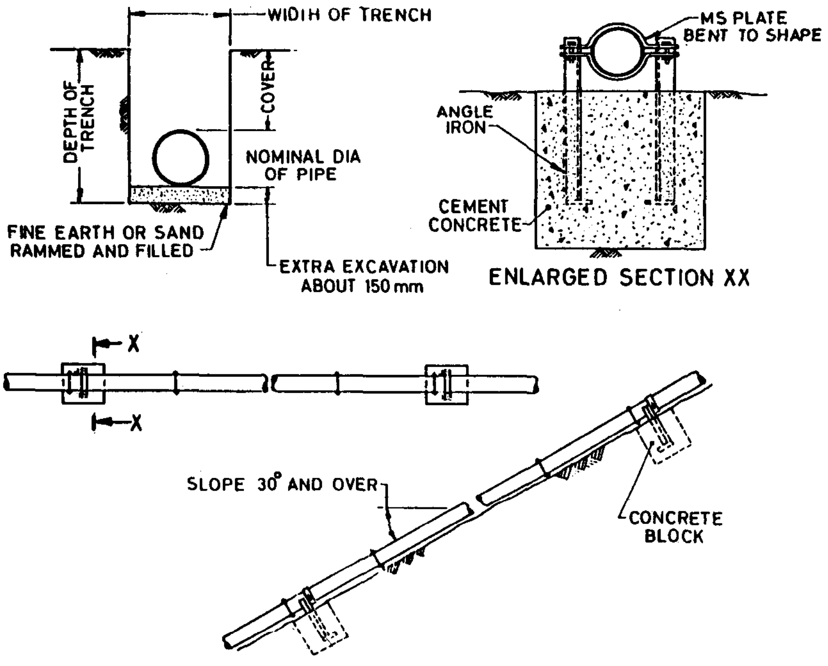


FIG. 19 LAYING OF AC PRESSURE PIPES IN ROCKS

7.4 Jointing of Asbestos Cement Pipes

7.4.1 Before commencing jointing, the pipes shall be cleaned; the joints and the ends of the pipe shall be cleaned, preferably with a hard wire brush to remove loose particles.

7.4.2 *Cast Iron Detachable Joints*

7.4.2.1 The joint shall consist of a central collar, two rubber rings, two flanges of cast iron and the required number of bolts and nuts.

7.4.2.2 One flange and rubber ring shall be placed on end of the pipe already laid, and the other flange, rings and central collar shall be slipped on to the pipe to be assembled (*see* Fig. 20).

7.4.2.3 The rubber ring shall be kept positioned at half the collar width less 2.5 mm from the end of the pipe already laid. A site gauge as shown in Fig. 20 may be used for convenience.

7.4.2.4 The other pipe shall be brought nearer leaving a gap of 5 mm between the two pipe ends. This gap will facilitate manouvering of deflection at joints atter assembly and will take care of any expansion in the pipe-line.

7.4.2.5 The collar shall be slided to sit square around the rubber ring on pipe 1 and then the rubber ring shall be rolled on pipe 2 to sit around the collar.

7.4.2.6 The flanges shall be moved on both ends to enclose rubber rings. The fastening bolts shall be inserted through the holes of the flanges and the bolts shall be tightened alternately and evenly for proper sitting of the joint.

7.4.3 *Asbestos Cement Coupling*

7.4.3.1 This joint shall consist of three rubber rings and an asbestos cement coupling machined on the inside.

7.4.3.2 The rubber rings shall be sealed in their respective grooves, after cleaning the coupling and rubber rings. The machined ends of the pipe and end rings in the coupling shall be suitably lubricated with a soft soap solution or other lubricant which is not deterimental to rubber rings or drinking water. Then, the assembly shall be made by pushing with a crowbar (*see* Fig. 21) or using a pipe puller.

7.4.4 The joints shall be made by keeping the pipes in one line. Any permissible deflection at the joint shall be made after completion of the joint only. The amount of deflection and the radius of curvature by successive deflection shall be as given in Table 6 (*see* Fig. 22).

7.4.5 Wherever necessary, change over from cast iron pipe to asbestos cement pipes and *vice versa* shall be done with the help of suitable adaptors (*see* Fig. 23).

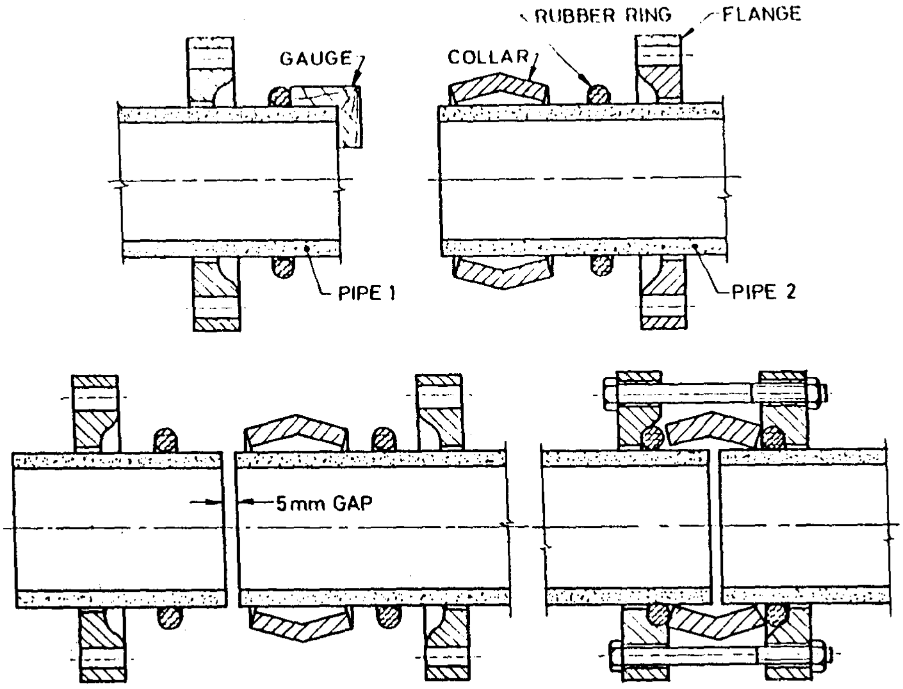


FIG. 20 CAST IRON DETACHABLE JOINT

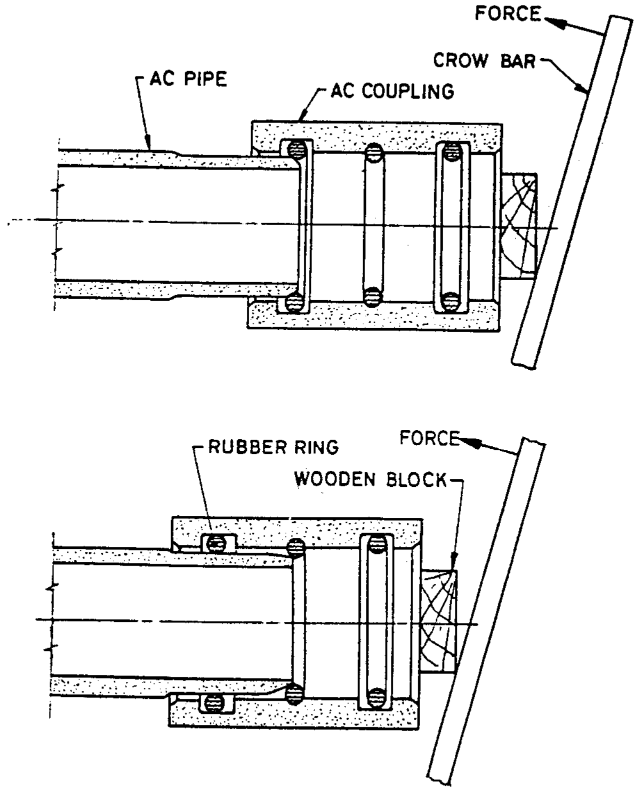


FIG. 21 ASBESTOS CEMENT COUPLING JOINT

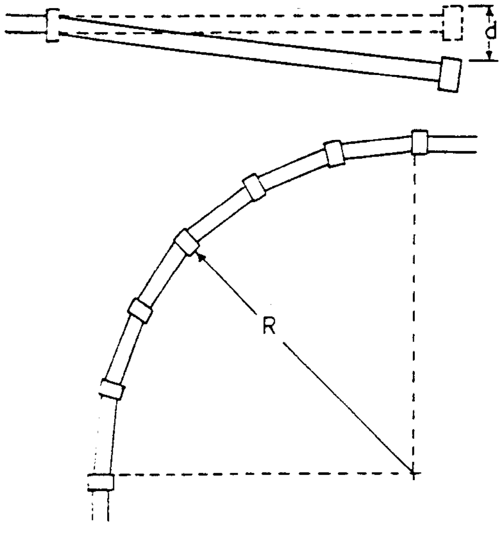


FIG. 22 DEFLECTION AND RADIUS OF CURVATURE BY SUCCESSIVE DEFLECTION OF PIPES

Table 6 Deflection and Radius of Curvature

(*Clauses* 7.4.4 and *Fig.* 22)

Angle of Deflection	Displacement *D* in mm for Pipe Length				Radius *R* of Curvature in mm for Pipe Length			
	1m	2m	3m	4m	1m	2m	3m	4m
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1°	20	35	50	70	60	120	180	240
2°	35	70	100	135	30	60	90	120
3°	50	100	150	200	20	40	60	80
4°	70	135	200	270	15	30	45	60
5°	85	170	250	335	12	24	36	48

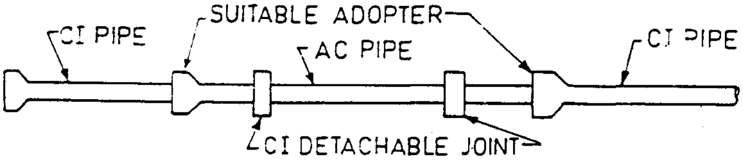


FIG. 23 LINE DIAGRAM SHOWING CHANGE OVER FROM CAST IRON TO ASBESTOS CEMENT PRESSURE PIPE

7.5 Thrust Blocks

7.5.1 Thrust blocks are required to transfer the resulting hydraulic thrust from the fitting or pipe on to a larger load bearing soil section.

7.5.2 Thrust blocks shall be installed wherever there is a change in the direction of the pipe-line, size of the pipe-line on the pressure-line diagram, or when the pipe-line ends at a dead end. If necessary, thrust blocks may be constructed at valves also.

7.5.3 Thrust blocks shall be constructed taking into account the pipe size, water pressure, type of fitting, gravity component of shell when laid on slopes and the type of soil. The location of thrust blocks for various types of fittings is given in Fig. 24.

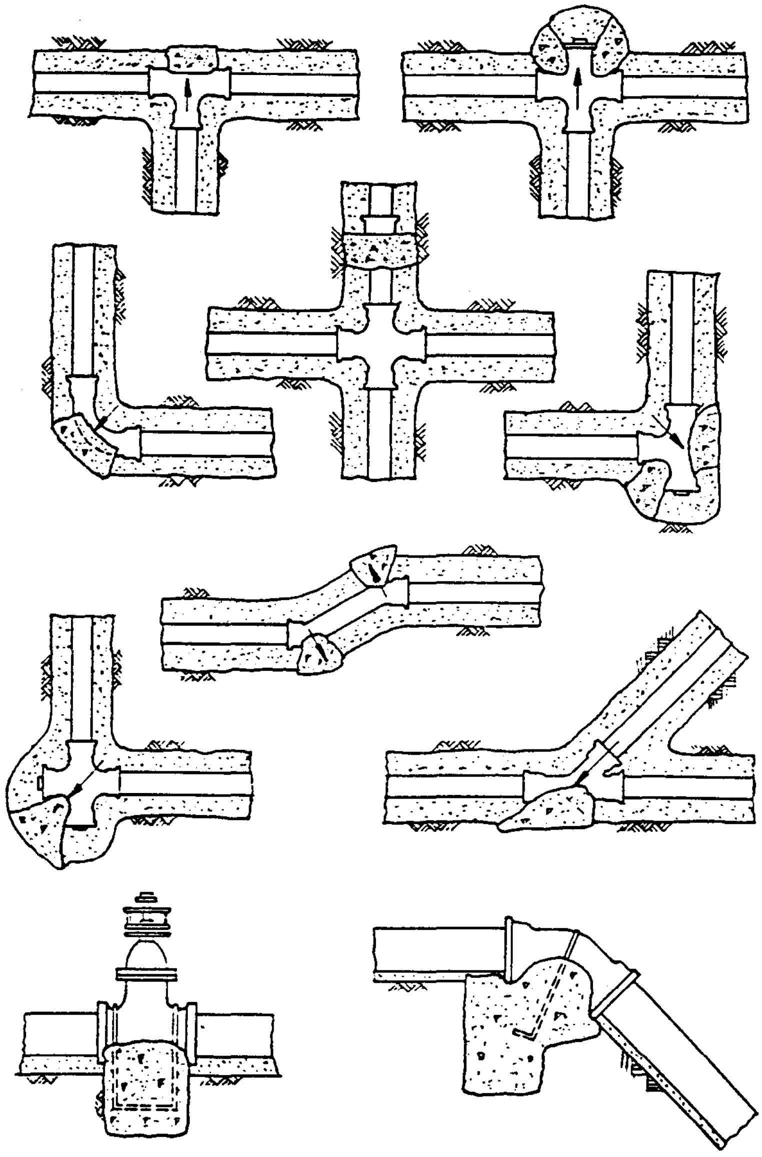


FIG. 24 LOCATION OF THRUST BLOCKS

7.5.4 When a fitting is used to make a vertical bend, it shall be anchored to a concrete thrust block designed to have enough weight to resist the upward and outward thrust. Similarly at joints, deflected in vertical plane, it shall be ensured that the weight of the pipe, the water in the pipe and the weight of the soil over the pipe provide resistance to upward movement. If it is not enough, ballast or concrete shall be placed around the pipe in sufficient weight to counteract the thrust.

7.5.5 When the line is under pressure there is an outward thrust at each coupling. Good soil, properly tamped is usually sufficient to hold pipe from side movement. However, if soft soil conditions are encountered, it may be necessary to provide side thrust blocks or other means of anchoring. In such cases only the pipe on each side of the deflected coupling shall be anchored without restricting the coupling.

7.5.6 Pipes on slopes need to be anchored only when there is a possibility of the backfill around the pipe sloping down the hill and carrying the pipe with it. Generally for slopes up to 30° good well drained soil, carefully tamped in layers of 100 mm under and over the pipe, right up to the top of the trench will not require anchoring. For steeper slopes, one out of every three pipes shall be held by straps fastened to vertical supports anchored in concrete.

7.6 Special Cast Iron Fittings and Accessories

7.6.1 Normally when pipe-line is laid, a certain number of cast iron fitting such as tees, bends, reducers, etc, and special fittings such as air or sluice valves are required.

7.6.2 *Laying of Fittings*

All cast iron fittings shall be plain ended to suit the outside diameter of asbestos cement pressure pipes and to the class and diameter of pipe manufactured. When using such cast iron fittings, they are jointed by cast iron detachable joints only. For any cast iron specials having flanges, they are jointed in the pipeline with cast iron flange adaptors having one end flanged and the other plain ended.

7.6.3 *Anchorages*

It should particularly be noted that the cast iron joints do not hold pipe ends within it firmly. During working at test pressure, there will be the tendency for the pipe ends or special ends to slip out of the joint, more so with the case of blank end cap used for closure of pipe-line and all degree bends and tees. In order to keep them firmly in the pipe-line, anchoring of these specials are necessary against the direction of thrust.

7.6.3.1 The anchorage shall consist of either concrete cast-in-situ or masonry built in cement mortar. The anchors shall be extended to the firm soil of the trench side. The shape of the anchors will depend on the kind of special used. They shall be spread full width of trench and carried vertically by the side and over the special to about 15 cm. The bearing area on sides of the trench will be proportional to the thrust and to the bearing capacity of the sides of the trench.

7.7 Service Connections

7.7.1 When the pipe is used in distribution house service, connections shall be provided through a saddle piece.

7.7.1.1 The saddle piece consists of two straps which envelopes the portion of pipe from where connection is to be given. The hole of required size shall be drilled through the pipe and the boss provided in the top strap. Ferrule piece shall be connected after making threads in the boss and pipe. Suitable rubber packing shall be used between the straps and the pipe to provide cushioning as well as sealing against leakages (*see* Fig. 25).

7.7.2 The size of the hole drilled in the pipe shall be limited to those given in Table 7.

Table 7 Size of Hole Drilled in Pipe

(*Clause* 7.7.2)

Pipe Size mm (1)	Maximum Size of Drilled Hole mm (2)
80 and 100	20
125 and 150	25
200	35
250 and above	50

8 LAYINGS AND JOINTING OF POLYETHYLENE PIPES

8.1 Laying

8.1.1 While installing the pipes in trenches, the bed of the trench should be level and free from sharp edged stones. While laying in rocky areas suitable bed of sand or pebbles should be provided. The initial back fill to about 10 to 15 cm above the pipe should be fines and/or screened excavated material. Where hard rock is met with, bed concrete M10, 15

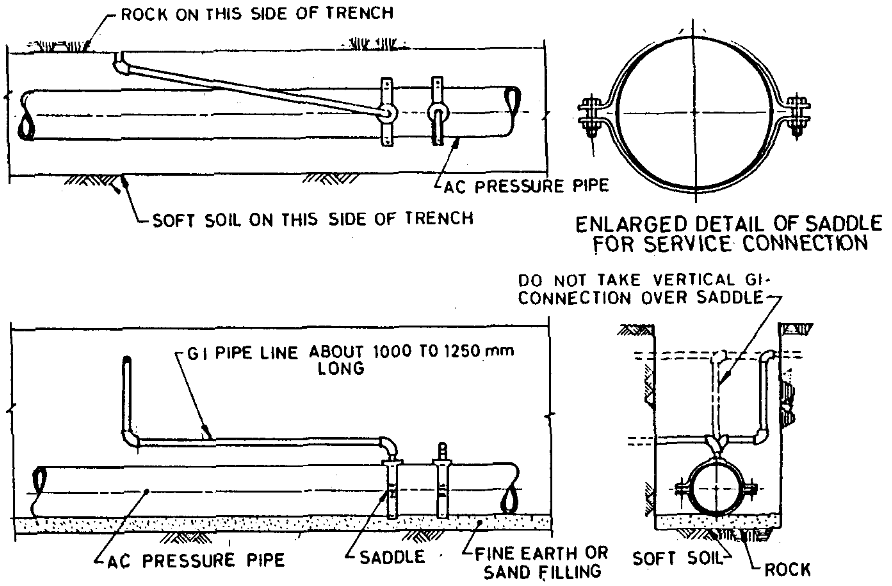

ROCK ON THIS SIDE OF TRENCH
AC PRESSURE PIPE
SOFT SOIL ON THIS SIDE OF TRENCH
ENLARGED DETAIL OF SADDLE FOR SERVICE CONNECTION
DO NOT TAKE VERTICAL GI-CONNECTION OVER SADDLE
GI PIPE LINE ABOUT 1000 TO 1250 mm LONG
AC PRESSURE PIPE
SADDLE
FINE EARTH OR SAND FILLING
SOFT SOIL
ROCK

FIG. 25 DETAILS SHOWING METHOD OF TAKING SERVICE CONNECTIONS FROM THE ASBESTOS CEMENT PRESSURE PIPE

cm thick may be provided, before putting in the soft sand/gravel.

8.1.2 Provisions shall be made for the effect of thermal movements between the anchors/supports.

8.1.3 Plastic pipes in general need not be painted. Painting may disguise its character. Hazard might occur by mistaking this pipe for metal one in using it for load bearning support, or for electrical grounding.

8.1.4 Plastic pipes shall not be installed near hot water pipes or near any other heat sources.

8.1.5 Plastic pipe clamps may be used to support the pipe. Pipe clips may also be used but care shall be taken not to over tighten and cause the clips to bite into the pipe. Pipe clips should be correctly aligned and should provide a smooth flat surface for contact with pipe. Sharp edged supports should be avoided. All types of manual controls, and valves in particular should be anchored firmly so as to minimize the turning movement imparted to the pipe by operation of the hand wheel (*see* Fig. 26).

8.1.6 *Support Spacing*

Supports for horizontal run, such as pipe clamps, brackets should be used at approximately the spacing given in Fig. 27.

8.1.7 *Effect of Temperature*

The coefficient of expansion is about twenty times (for low density polyethylene pipes) and fourteen times (for high density polyethylene pipes) than the expansion experienced with metal pipes. This also holds good for contraction due to fall in temperature.

In many instances the normal changes in the direction of the pipe provide an adequate means of accommodating expansion.

In continuous straight runs of pipe it is necessary except where pipes are laid underground to insert units to absorb the expansion. Expansion loops, bellows or sliding gland expansion joints may be used.

Care should be taken to account for the high increase in surface temperatures of these pipes in cases of exposed laying or laying in the close proximity of artificial heat sources.

8.2 Jointing Techniques

8.2.1 The commonly used joints are as follows:

a) Insert type joints,

b) Compression fittings,

c) Fusion welding,

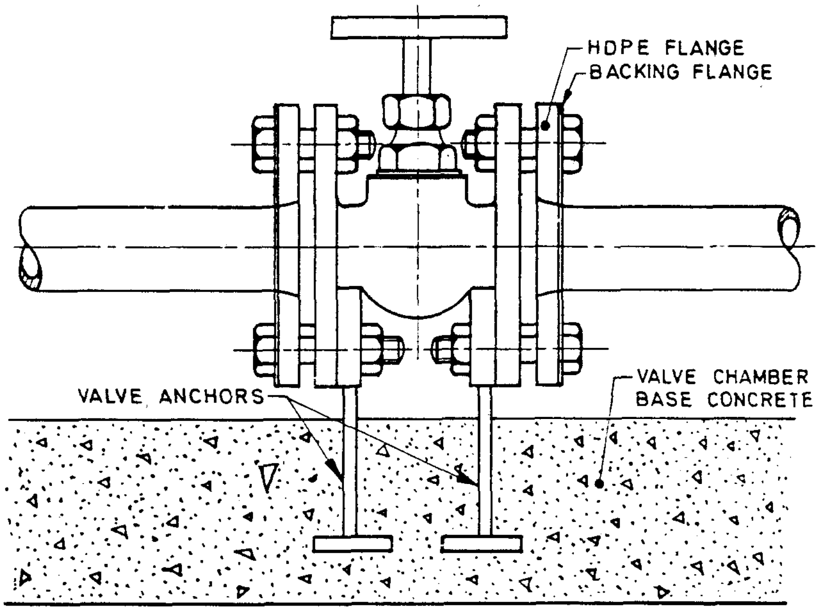
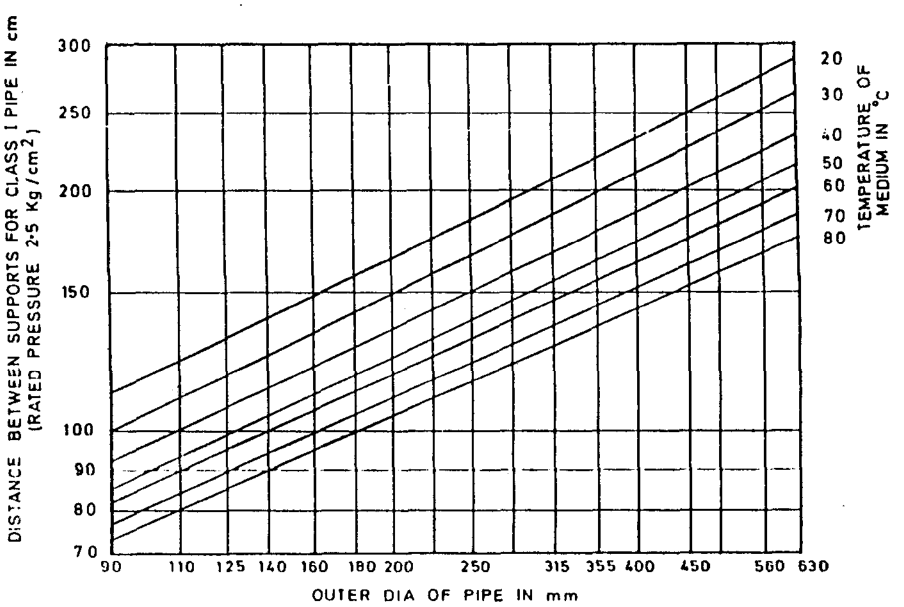


FIG. 26 VALVE CHAMBER DETAIL



NOTE — The values from graph are to be multiplied by :
1.0 for HDPE pipe rated pressure 0.4 MPa (4 kgf/cm²) (Class II),
1.1 for HDPE pipe rated pressure 0.6 MPa (6 kgf/cm²) (Class III), and
1.25 for HDPE pipe rated pressure 1.0 MPa (10 kgf/cm²) (Class IV).

FIG. 27 DISTANCE BETWEEN PIPE SUPPORTS FOR HDPE PIPE FOR TRANSPORTATION OF WATER/WASTE WATER

d) Threaded joints,
e) Flanged joints, and
f) Telescopic joints.

8.2.1.1 There are insert type of fitting of both plastic and metals available for use with PE pipes. In corrosive locations plastic fittings are preferred because of their high resistance to corrosion. In less corrosive conditions gun metal fittings are frequently used and in normal or slightly corrosive environments, brass fittings are commonly employed. In certain cases, threaded malleable cast iron fittings are used.

8.2.2 *Insert Type Joints* (*see* Fig. 28)

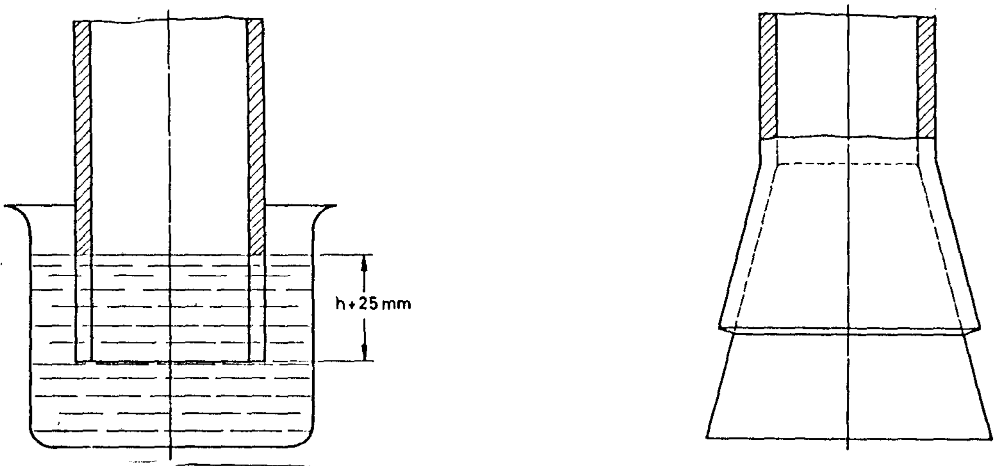
8.2.2.1 These are commonly used for LDPE pipes wherein a serrated PE or metallic fitting is inserted into the pipe and tightened by a clip.

8.2.2.2 The outer serrations of HDPE/metal insert type fittings lock into the PE pipes to prevent their coming out under sudden pressure surge. If the pipe bore is slightly undersized, a little heating by immersion in boiling water in case of LDPE and oil bath (130°C) in case of HDPE would soften the pipe to enable insertion of fitting. If the bore of the pipe is loose, the bore clip of worm drive type will secure the fitting and ensure a leak proof joint. The insertion of these fittings into the bore of the pipe is done with hand pressure only. As a measure of safety, worm drive type clip should be used in all cases. This type of jointing is used normally in small diameter pipes up to 110 mm.

8.2.3 *Compression Fittings*

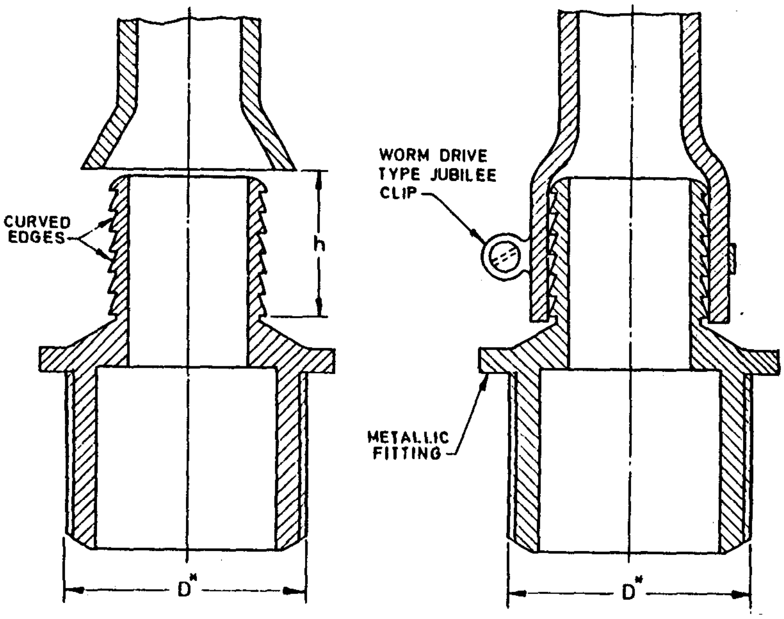
8.2.3.1 They are used for LDPE and HDPE joints. They are detachable joints and are made of metals or plastics.

8.2.3.2 In the majority of cases the metal fittings are based on the type of compression fittings commonly used with copper tubes. In this type of joint the dimensions of the pipe are generally not altered. The joint is effected by an internal liner and a compression ring or sleeve which shrinks and therefore compresses the pipe wall on to the liner,



28 A HEATING IN OIL BATH

28 B FLARING ON THE CONE



28 C INSERTING FLARED PIPE ON THE SERRATED FITTING

28 D COMPLETED JOINT

D* — Pipe OD suiting to standard steel pipe.

FIG. 28 TYPICAL ILLUSTRATION OF MAKING INSERT TYPE JOINTS FOR HDPE PIPES

thus gripping to the wall of the pipe. The liner and compression sleeve may also be an integral unit (*see* Fig. 29).

8.2.3.3 In other cases the flared pipe wall is compressed on a conical insert either by two male and female threaded metallic nuts (*see* Fig. 30A) or by backing loose flanges (*see* Fig. 30 B). The water seal is made by compression of ends of PE flared pipe between sloping surface of metallic nuts/flanges and conical inserts.

8.2.3.4 *Compression joints with collar pipe ends and flat gaskets*

Aluminium alloy or brass fittings with male and female coupling parts are available for jointing with metallic fittings. The male and female ends of the coupling are inserted face to face on two ends of the pipes to be jointed. Collars are made on the pipe ends by heating the ends with hot plate or electric coil. The two collars are brought together and the female end of the coupling is tightened on the male end. A water tight seal is

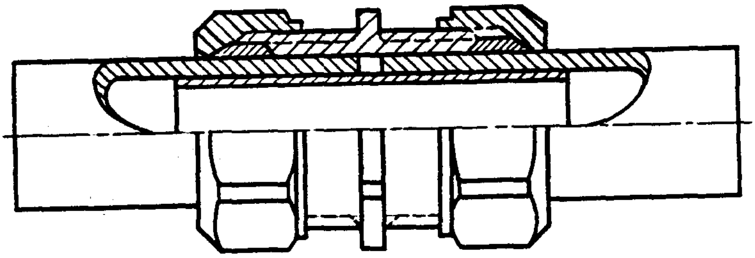
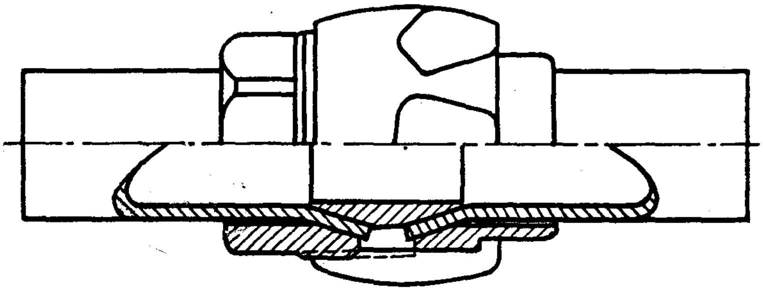
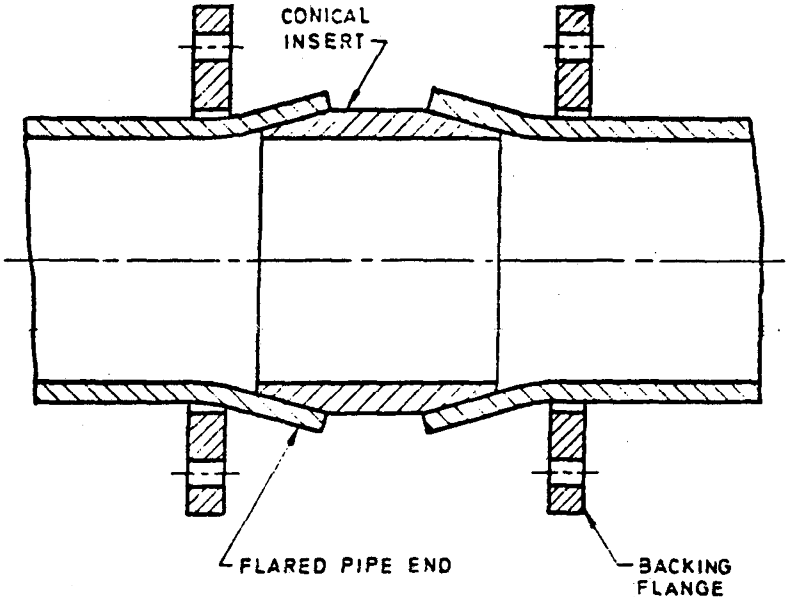


FIG. 29 COMPRESSION FITTING (TYPE 1)



30A FLARED JOINTS WITH METALLIC NUTS



30B FLARED FLANGED JOINT

FIG. 30 COMPRESSION FITTING (TYPE 2)

made between the flanges. This is a detachable type of jointing and is practicable up to 50 mm dia pipes (*see* Fig. 31).

8.2.4 *Fusion Welding*

8.2.4.1 Fusion welding is commonly used in HDPE and is a permanent type of joint.

8.2.4.2 *Procedure of butt welding of HDPE pipes*

The pipe should be cut square and the face of the pipe should be slightly scraped prior to welding to remove oxidized layer. At the time of welding, levelling of the pipes is essential particularly in case of larger diameter pipes. Welding temperature should be 200°C and surface of heating mirror should be 210° ± 5°C [heating mirror is a metallic plate heated up to the required temperature either by electrical coil embedded inside or by blow torch. The word mirror has come because this hot plate radiates heat (*see* Fig. 32)]. 'The pipes to be welded should be held on either side of the heating mirror with only contact pressure of about 20 kPa (0.2 kgf/cm^2).' When the rim of molten material is found, the pipes are removed from the heating mirror and immediately the joint is made by application of moderate pressure of approximately 0.1 to 0.2 MPa (1 to 2 kgf/cm^2) for 2 to 3 seconds. The initial heating time for achieving molten rim, varies from 1 to 5 min depending upon the pipe wall thickness and size.

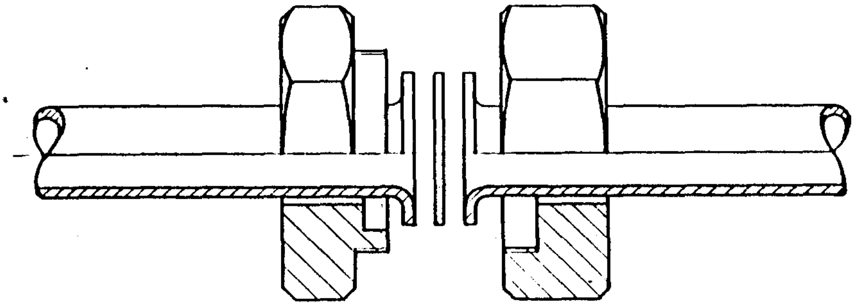
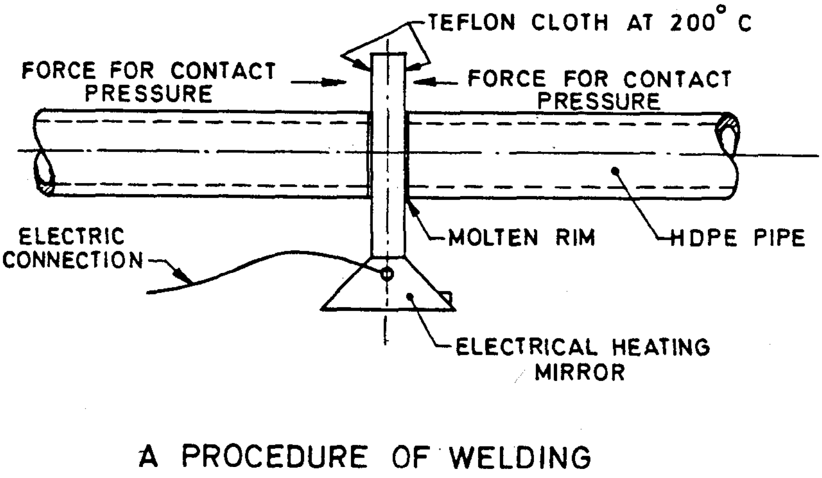
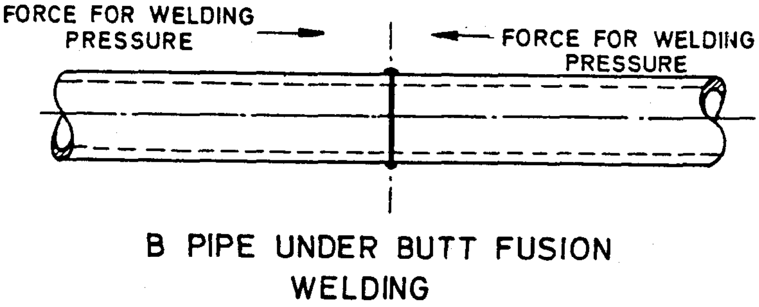


FIG. 31 COMPRESSION JOINT WITH COLLAR/PIPES ENDS AND FLAT GASKET



32A PROCEDURE OF WELDING


FORCE FOR WELDING PRESSURE
FORCE FOR WELDING PRESSURE
B PIPE UNDER BUTT FUSION WELDING

32B PIPE UNDER BUTT FUSION WELDING

FIG 32 PROCEDURE OF BUTT WELDING OF HDPE PIPES

Following precautions should be taken while applying this procedure:

a) It is essential to see that the rim formed is not excessive.

b) While jointing, the pressure should be maintained until the joint is luke-warm and after the pressure is relieved, the joint is allowed to cool completely.

c) The mirror should be kept exactly around 210°C which needs about 30 min time (for electrical mirror). It is also essential to see that the temperature is maintained constant by the proper setting of regulator. For detecting the correct temperature, crayon chalk is used. For example at 210°C the colour of crayon dot on the mirror changes within 2 seconds. But the dot made should be thin and if not, time taken will be more, indicating a wrong temperature.

A satisfactory butt welded joint of HDPE will have the strength factor of one. Temperature is of primary importance and weld efficiency may decrese if the temperature does not fall with in the range of 200 ± 10°C.

8.2.5 *Screwed Joints (Threaded Joints)*

8.2.5.1 These can be used for LDPE and HDPE pipes with higher pressure ratings which have thicker walls. It should be noted that such threading reduces the factor of safety and hence working pressure in the lower classes will have to be assumed for design purposes. Ordinary metal cutting dyes of adjustable and guided variety may be used. As far as possible, a full thread should be cut in one operation. It is advisable to plug the end of the pipe during threading operation to avoid distortion due to flexibility. When threading the pipe, taper threads should be used and only the exact number of threads required for the joint should be cut so that when the joint is made, all the threaded portion of the pipe is totally enclosed in the fitting.

8.2.5.2 Galvanized iron fittings are suitable where there is no risk of corrosion. In corrosive conditions, PE or other corrosion-resistant material fittings should be used.

8.2.5.3 Under no circumstances should steel pipe wrenches be used on a plastic pipe or fitting.

8.2.6 *Flanged Joints*

8.2.6.1 These are used for jointing LDPE and HDPE pipes particularly of larger size to valves and vessels and large size metal pipes where strength in tension is required.

8.2.6.2 It consists of flanges either loose or welded to the pipe ends. It is recommended that suitable metallic backing plates be used to support the polyethylene flanges to enable them to be bolted together. Injection moulded polyethylene flanges with metal inserts of 6 to 9 mm thickness may also be used. In most cases, sealing is improved by incorporating a natural or synthetic rubber gasket between polyethylene flanges (*see* Fig. 33).

8.2.7 *Telescopic Joint (see* Fig. 34*)*

8.2.7.1 Any joint (socket and spigot type) that permits sliding of the free end (spigot end) inside the socket with a rubber or suitable gasket, without any leakage is called telescopic joint.

8.2.7.2 The socket could be an integral part of the pipe at one end or two ends or a special coupler into which the free ends (spigot ends) of the pipes are pushed to achieve a water tight joint.

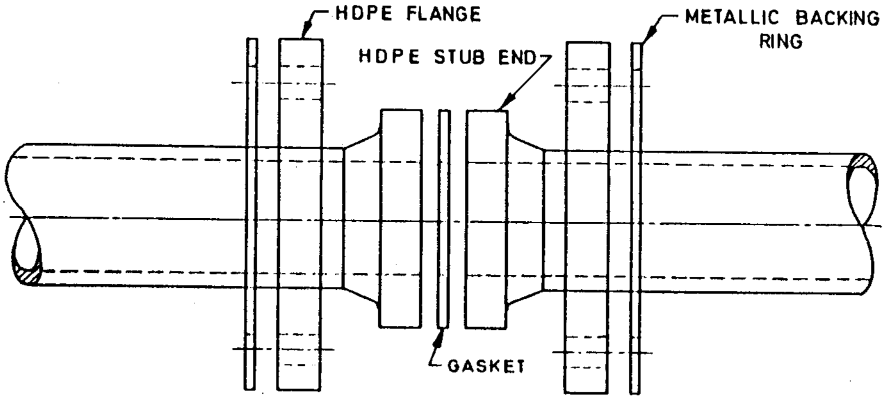


FIG. 33 FLANGED JOINT

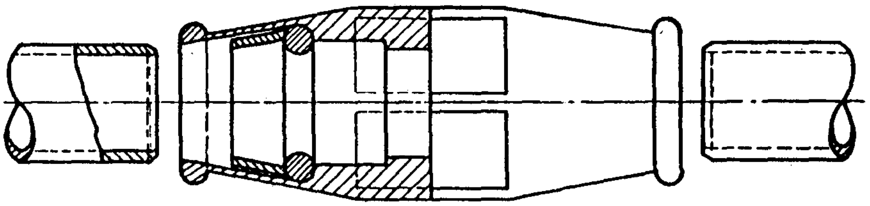


FIG. 34 TELESCOPIC JOINT

8.2.7.3 These joints are normally weak in longitudinal pull and hence need anchoring wherever such a tendency of longitudinal pull is likely in the pipe-line. In the case of telescopic joints, one external anchorage is generally necessary at each end of the pipeline, at valve and at all changes of direction. The supports of the side connection should ensure that excessive lateral bending does not occur. In small diameter the coupler itself could be modified to have a split, threaded, grip type gasket of hard materials in addition to 'O' ring type of rubber gasket (for water tightness) to prevent any slipping out of the free end of the pipe in longitudinal pull.

8.3 Bending

8.3.1 *Cold Bending*

Small diameter PE pipes have a degree of flexibility such that a substantial radius may be set up within a length of pipe itself without heating, and without causing residual stress.

8.3.1.1 This enables gradual curves to be negotiated without the need for special bends or flexible couplings. In low density PE pipes an inside radius of not less than 12 times the outside diameter of the pipe is permissible. In case of high density PE pipes the radius of the bend shall be greater than 20 times the outside diameter of the pipe. Cold bends should only be used on pipes operating at ambient temperatures.

8.3.2 *Hot Bending*

8.3.2.1 Forming of small radius bend may easily be done by the application of heat either by hot air oven or by immersion in a suitable liquid at an appropriate temperature. For low density, the temperature range is 100° to 110°C and suitable liquids are water, glycerol or a solution of calcium chloride. Higher density PE pipe should be heated in an inert liquid, such as glycerol (or any oil in emergency) at a temperature of 130°C. Electrical heating coils or plates may be used only by experienced technicians.

8.3.2.2 In preheating operations, the low thermal conductivity of PE should be kept in mind. Over heating can usually be recognized by surface discolouration and distortion. On the other hand bending operations should not be performed at too low a temperature, because of excessive stress that could result. Naked flames for heating should be used only by experienced operators.

8.3.2.3 At bending temperature, the bore of the pipe tends to collapse and therefore requires support during the bending operation. Internal support should be effected before heating by packing the bore of pipe with warm fine dry sand or by inserting rubber pressure hose, rubber rod, or a flexible spring. After the pipe is uniformly heated, it should be pulled around a simple jig and held in the correct position until it cools off.

8.3.2.4 It is recommended that radius of the bend for pipes up to 50 mm size should not be less than three times the outside diameter of the pipe for low density PE and five times the outside diameter for high density PE. Pipes of large diameter will require an increase in radius.

9 LAYING AND JOINTING OF PVC PIPES

9.0 Laying of PVC Pipes

9.1.1 Procedure given in **2** is to be followed for preparing site and trenches.

9.1.2 Where ovality of the pipes occur, it should be rectified before laying in position.

9.1.3 While installing the pipes in trenches the pipes should be bedded in sand free from rock and gravel.

9.1.4 Provision shall be made for the effects of thermal movement. Between the anchors for suspended pipes the supports should not grip or distort the pipe, but should allow the repeated longitudinal temperature movement to take place without abrasion. Line or point contact with the pipe should be avoided. Heavy components, such as metal valves should be individually supported.

9.1.5 In the case of telescopic joints one external anchorage is generally necessary at each end of the pipe-line, at valve and at all changes of direction. The supports of the side connection or bend should ensure that excessive lateral bending does not occur.

9.1.6 Plastic pipes in general need not be painted. Painting may disguise its character. Hazard might occur by mistaking this for metal one in using it for load bearing support, or for electrical grounding. Also use of certain paints can cause damage to PVC pipe.

9.1.7 Plastic pipes shall not be installed near hot water pipes or near any other heat sources.

9.2 Jointing Techniques for PVC Pipes

9.2.1 Unplasticized PVC pipe is made by continuous extrusion process and is generally available as rigid (hard) in factory cut lengths.

9.2.1.1 Satisfactory jointing plays an important role in successful application of these pipes. The commonly used joints are as follows:

a) Solvent welded joints,

b) Flanged joints,

c) Screwed or threaded joints, and

d) Rubber ring joints.

9.2.2 *Solvent Welded Joints*

9.2.2.1 These are permanent in nature and strong in tenstion. They are used for service pipes of water mains. These joints are commonly used and economical for PVC pipe works.

9.2.2.2 This technique is used with both spigot and socket type joints, in which the socket is made specially to form a close fit on the pipe end and with injection moulded fittings.

9.2.2.3 Solvent cement consists essentially of a solution of vinyl polymer or copolymer dissolved in a suitable volatile mixture or organic solvents. The solvent constituents soften the mating surfaces, which diffuse into one another to form a 'cold weld'. Such chemicals are available with chemical resistance equal to that of the pipe. For solvent cements available in India, it is recommended by manufacturers that full load could be given only after 24 hours. Further guidance may be obtained from the respective manufacturers.

9.2.2.4 The solvent welded joint may be achieved either by heat application method or by non heat application method. The non heat application method is easier and is recommended for water supply installations. A typical illustration of solvent welded joint is shown in Fig. 35. The details of the two methods are as given below:

(i) *Non heat application method*

a) In this method, instead of forming a socket on one of the pipe ends by heat application, an injection moulded socket fitting or coupler is used. This socket fitting has a provision to take in the pipe normally on either ends. The solvent cements are applied on the surfaces to be jointed and the joint is made at the ambient temperature. The fabricated fittings are inferior to the injection moulded ones, and wherever possible only injection moulded fittings should be used.

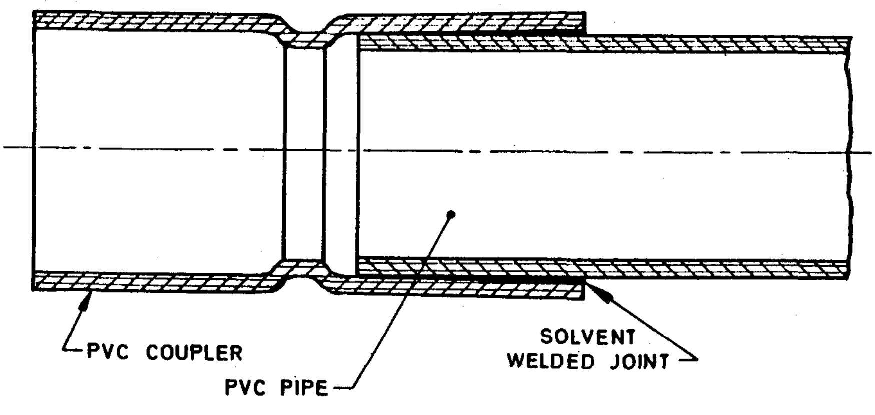


FIG. 35 PVC SOLVENT WELDED JOINT

b) The pipe should be cut perpendicular to the axis of the pipe length with a metal cutting saw or an ordinary hand-saw with a small teeth. Pipe ends have to be bevelled slightly with a bevelling tool (reamer) at an angle of about 30°. The total length of insertion of socket shall be marked on pipe and checked how far the pipe end could be inserted into the fitting. Usually the pipe end should go into the fitting socket (with a taper inside) up to $\frac{1}{3}$ to $\frac{2}{3}$ of the socket length.

c) Dust, oil, water, grease, etc, should be wiped out with dry cloth from the surfaces to be coated with solvent cements. After that the surface should be degreased thoroughly with a suitable solvent, such as methylene chloride. The coating of solvent cements shall be applied evenly on the inside of the fitting for full length of insertion and then on the outside of the pipe end up to the marked line. For hot and dry climate thicker coatings should be applied. The pipe should be pushed into the fitting socket and held for 1 to 2 minutes as otherwise the pipe may come out of the fitting due to the slippery quality of cement and the tapering inside bore of the fitting. The surplus cement on the pipe surfaces shall be wiped out.

d) In most of the cases, the pipe inserted should be up to the marked line and in no case shall be less than 2/3 of the length of the pipe end up to marked line. When solvent welding the pipes, the spigot end should always be fully inserted into the socket. If this cannot be done, either the solvent cement has dried up too much or the tapering of the socket is too steep.

e) In hot climates with a larger temperature difference between day and night it is advised to make the joints early in the morning or in the evening when it is cooler. Thus the joints are prevented from being pulled apart again when the pipe cools off at night. After making the joints, the trench with the pipe should be covered with the soil as soon as possible to ensure an even temperature for the system.

(ii) *Heat application method*

a) This method of jointing makes use of spigot and socket shapes of the pipes. The female end is bevelled on the bore. The other pipe end (male end) to be inserted is bevelled at an angle of 20° to 30° on the outer periphery. The tool used for bevelling may be a reamer or a blade or a pen knife. One of the pipe ends (female end) is expanded by heating a length of 1.5 times the diameter of the pipe to a temperature of 130°C by blow torch, salt saturated bath or any other suitable medium maintained at that temperature. The male end is inserted inside the softened female pipe end. A plug gauge may be used to prevent distortion. The heat application may be in one or two-step methods described in (b) and (c).

b) In the one step method, a little before heating is complete, a thin coat of slow drying solvent cement is applied evenly on the inside surface of female end of pipe and the outside surface of the male end of pipe for a length of about 1.5 time the diameter. After the insertion is complete, the joint is cooled with water or a wet cloth.

c) In the two-step method, the initial insertion as described under non-heat application method above, is done without solvent cement application. After cooling, the pipes are separated, roughened with sand paper and cleaned with a suitable solvent such as methylene chloride. The pipe ends are coated with solvent cement and pushed into the socket firmly.

d) *Precautions* :

1) Where blow torch is used, care should be taken not to overheat the pipe as it would damage and weaken the pipe.

2) Before applying the solvent cement, wiping out of dust, oil, grease and moisture is very essential.

3) When the joint is made, the remaining cement on the pipe surface should be wiped off immediately without fail, as the continued action of solvent cement will weaken the wall of the pipe and cause failue under pressure.

4) Since solvent cements are inflammable, they should not be used near naked flames. In certain cases, flames given off from cement may be a source of danager, if the operation is not carried out in a well ventilated area.

5) When not in use containers of cement should be kept closed tightly to avoid

loss of solvent or entry of dirt. Cement which has gelled or hardened should be discarded.

9.2.3 *Flanged Joints*

These are used for jointing of PVC pipes particularly of larger sizes to valves and vessels and larger size metal pipes where strength in tension is required. The joint is made by the compression of a gasket or a ring seal set in the face of the flange. The flange may be formed in several ways as under:

a) By upsetting the pipe end on a mandrel after heating the pipe ends. A backing ring of metal or thermoset plastic compresses the up set pipe end on to the fitting face of the gasket. Crinkles are formed too easily in the collar and the whole unit loses much of its strength.

b) By solvent cementing a plastic stub flange on to the pipe end and again using a backing ring. The pipe end may also be welded to the PVC flange. A typical illustration is shown in Fig. 36.

c) By solvent cementing a plastic full faced flange on to the pipe end and bolting this to be the fitting face. A backing ring or wide washers should be used to distribute the bolt loads. This prevents the distortion of the PVC flange. A typical illustration of the type of connection is shown in Fig. 37.

9.2.4 *Union Joint*

This is a form of flanged joint but the faces are held together by a screwed connection. A composite metal and PVC socket union is a very satisfactory method of jointing PVC to screwed metallic fittings. A typical illustration of union joint is shown in Fig. 38.

9.2.5 *Screwed Joints*

9.2.5.1 These are similar to the joint used with metal pipes. If pipe has to be jointed by screw threads, only thick walled pipe should be used and cut with taper pipe threads. The die should be clean and the thread should be made in one pass. The threaded pipes shall not be subjected to pressures exceeding two-thirds of the pressure rating for unthreaded pipes.

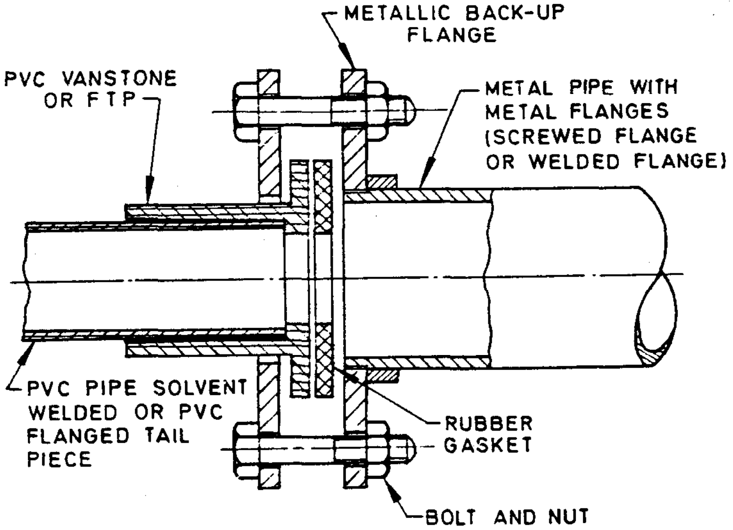

METALLIC BACK-UP FLANGE
PVC VANSTONE OR FTP
METAL PIPE WITH METAL FLANGES (SCREWED FLANGE OR WELDED FLANGE)
PVC PIPE SOLVENT WELDED OR PVC FLANGED TAIL PIECE
RUBBER GASKET
BOLT AND NUT

FIG. 36 FLANGED JOINTS WITH PVC

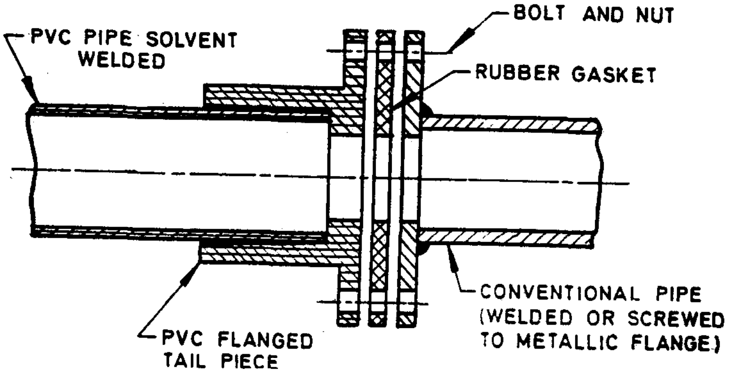


FIG. 37 FLANGE JOINTS. JOINTING PVC PIPES AND OTHER CONVENTIONAL PIPES USING PVC FLANGED TAIL PIECE

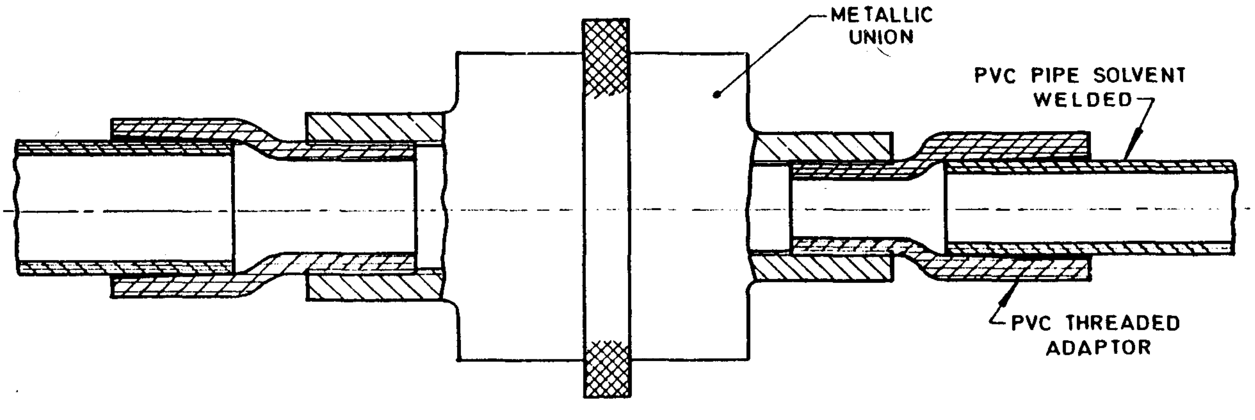


FIG. 38 UNION JOINT

9.2.5.2 Short pieces of thick walled pipe may be threaded at one end and solvent cemented on to normal walled pipe at the other end to make the connector pieces to screwed metal fittings. This system may be used up to 50 mm in outside diameter.

9.2.5.3 Jointing with hemp and paste shall not be used. The joint should be made to firm hand tightness using only strap trenches.

9.2.5.4 There is no well defined increase in the tightness at assembly as there is with metal to metal fittings and these joints can therefore very easily be over strained.

9.2.5.5 Injection moulded threaded joints are used for jointing PVC to metal pipes. Cutting of threads into PVC pipes is not recommended as these pipes are notch sensitive. Unplasticized PVC pipes may be moulded and jointed in the same way as the metal pipes. But the PVC material is very notch sensitive and therefore cutting of screw threads into PVC pipe is not recommended. Injection moulded threads are however less notch sensitive.

PVC to metal connection with threaded joints should be made with the PVC as the male components of the joint. PVC as the female component may be used only when specific arrangements are made to prevent over tightening or where both the threads are of parallel form and the fluid seal is made by a separate ring or gasket. A typical illustration of the type of joint is shown in Fig. 39.

9.2.6 *Fixing Water Tap to PVC Pipes*

While connecting metallic water taps to the PVC pipes in domestic plumbing, it is recommended to use a metallic coupler to the tap and then connect the same to the PVC pipe using injection moulded threaded joints. The metallic part alone is supported and not the PVC. The unsupported length from the face of the wall should not be more than 10 cm for satisfactory operation and a strong coupling be provided on the face of the wall at the point of overhang. For any repairs to the tap, the tap should be removed from the metal coupler to avoid working on

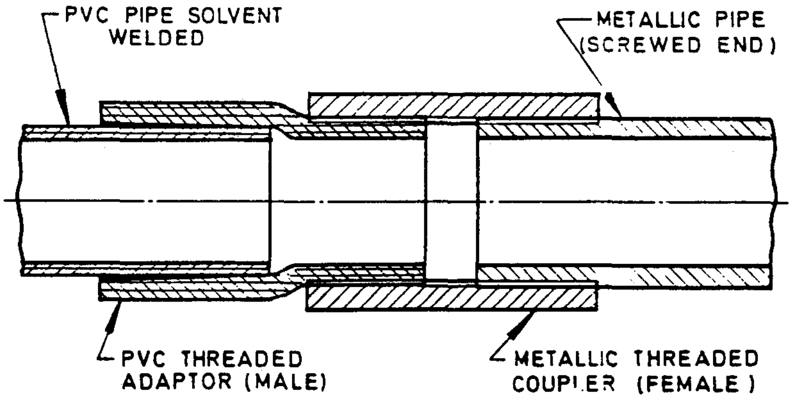

PVC PIPE SOLVENT WELDED
METALLIC PIPE (SCREWED END)
PVC THREADED ADAPTOR (MALE)
METALLIC THREADED COUPLER (FEMALE)

FIG. 39 JOINTING PVC PIPE TO CONVENTIONAL PIPE

it insitu. A typical illustration of connection is shown in Fig. 40.

9.2.7 *Rubber Ring Joints*

9.2.7.1 Rubber ring joints can provide a water tight seal but are not designed to resist pull. In the case of these joints, the rubber and the fluid to be transported should be compatible. The material of rubber rings should conform to IS 5382 : 1985. Where aggressive soils are met with, synthetic rubbers perform better. Generally speaking, rubber ring joints are used for large sized pipes (63 mm and above). Such joints may be provided on pipes which are buried in the ground and supported throughout on a bedding so that they are not subjected to movement and longitudinal pull.

9.2.7.2 The strength of a rubber ring joint to longitudinal forces is not high and for same joints a flange or a shoulder is made on the pipe end to provide the necessary strength in tension. For buried water supply mains the installed pipes and joints are supported by the continuous bed of the trench and no tensile strength in the joint itself is necessary. However, care shall be taken to anchor the pipe and fittings at bends and at connections to valves. If used above ground, they shall be anchored to provide the required strength.

9.2.7.3 Unplasticized PVC pipes may be jointed by methods employing a rubber ring to provide the water tight seal. The ring may be housed in groove formed in a plastic or metallic housing. The rubber is commpressed and makes a seal between the pipe and the housing. The ring shape and the method of compressing the ring vary considerably in different types of joints. Most joints often require the application of lubricating paste. Where natural rubber rings are used, mineral oils or petrol or grease of any type should, on no account be used.

9.2.7.4 The following are some of the types of rubber ring joints:

a) Insertion joints:
   1) With spigot and socket, or
   2) With separate collar pieces having two rubber rings, one at either end,

b) Lip seal joints;

c) Wedged joints; and

d) O-ring shrink joints.

9.2.7.5 *Storage*

Following precaution shall be taken for storage of rubber rings, gaskets, etc:

a) At all times rubber rings and gaskets and all other fittings shall be stored so as to avoid damage of any kind to them or contamination by oils, petrol or greases.

b) All rubber items should be stored in a cool, dry and dark place. When not in use, containers of lubricant should be kept closed tightly to avoid entry of dirt.

9.2.8 *Service Connections*

9.2.8.1 Both metal and plastic saddles are available for the off take of service connections from larger bore pipes (50-mm diameter and above). One type of saddle consists of a half round moulded unplasticized PVC section which is solvent cemented to the pipe surface. The outside of the PVC section has a boss on to which the service connection may be screwed. Another type consists of two half round sections of metal or PVC which are bolted together or held round the pipe by wedge grips. A seal is formed between the saddle and the pipe by rubber O-ring compressed between the pipe and the under surface

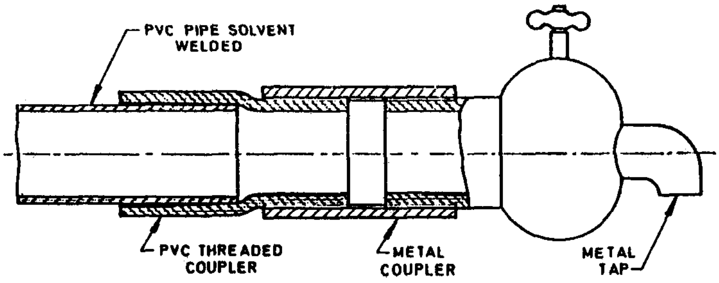


FIG. 40 CONNECTION OF PVC PIPE TO METALLIC WATER TAPS

of the upper section. The service connection is taken from a boss on the upper section.

9.2.8.2 Conventional equipment for tapping under pressure may be used with these service connections using a special trepanning cutter to pierce the pipe wall. Some ferrules have self contained cutter for this purpose. Ferrules should not be screwed directly into unreinforced pipes without the introduction of a reinforcing saddle piece. A typical illustration of a ferrule connection is shown in Fig. 41.

9.3 Forming and Bending

9.3.1 *Hot Forming*

9.3.1.1 The thermoplastic nature of the unplasticized PVC enables the material to be manipulated and formed to shape after heating to temperature between 125°C to 140°C. On cooling, the material will become rigid and will retain its reformed shape.

9.3.1.2 When in softer state the material will be capable of considerable deformation and may be formed to the desired shape with ease. Pipe may be worked to form bends, off sets or taper sections. Increase or reductions of pipe diameters can be effected and pipe ends may be belled or flared as required using formers of suitable shape.

9.3.1.3 PVC is a poor conductor of heat and in consequence of this care shall be exercised when heating to allow sufficient time for the heat to penetrate the thickness of the material. Visual indication of temperature is difficult but when correctly heated the material becomes rubber like to touch. On no account attempt be made to form the material in temperature less than that required (under **9.3.1.1**). Heating may be carried out in hot air ovens by radiant heat, aromatic free oil bath, self saturated bath or by any other suitable method. A blow torch may also be used, care being taken to avoid local overheating which will cause discolouration of the material and subsequent charring of the surfaces. Whichever form of heating is used, the article should not be removed from the jigs or formers until complete cooling has been effected, otherwise a tendency for the material to revert to its original shape will occur.

9.3.1.4 While bending at the forming temperature the pipe bores tend to collapse and will therefore require support during the forming operation. Internal supports should be effected before heating by packing the bore of the pipe with warm fine dry sand, a rubber pressure hose, or rubber rod of the correct diameter or by any other suitable means.

9.3.1.5 After heating the pipe uniformly it should be pulled around a simple wooden jig and held in the correct position. It is then cooled externally with air or water until it is set.

9.3.1.6 The bending of small diameter pipes may also be done on the horizontal mould plate with the required radius clearly marked on it.

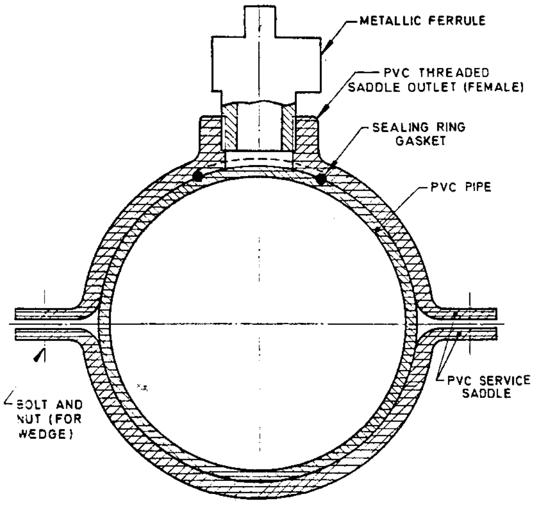


FIG. 41 FERRULE CONNECTION (USING PVC SERVICE SADDLE)

9.3.1.7 It is recommended that the centre line radius of the bend for pipes up to 50 mm diameter should not be less than three times the nominal diameter of the pipe. Pipes of larger diameter will require an increase in radius to the order of five times the nominal diameter.

9.3.1.8 Hot forming at site is not recommended.

9.4 Support Spacing

Recommended support spacings for unplasticized PVC pipes are given in Table 8. These are based for conveyance of cold water. For vertical runs support spacing may be increased by 50 percent.

Table 8 Minimum Supports for Unplasticized PVC Pipes
(*Clause* 9.4)

All dimensions in millimetres.

Outside Dia (1)	20°C (2)	40°C (3)
16	750	675
20	780	700
25	825	750
32	900	825
40	1 050	975
50	1 125	975
63	1 200	1 000
75	1 275	1 125
110	1 500	1 425
125	1 800	1 650
140	1 875	1 725
180	1 950	1 800
200	2 025	1 875
225	2 100	1 950
250	2 175	2 025

9.5 Anchorage

Suitable anchor blocks should be provided at all changes in the direction of the pipe-line and wherever else required to withstand thrust resulting from the internal water pressure at blank ends. Valves and hydrant tees should be supported in such a manner that the torque applied in operating a valve is not transmitted to the pipe-line.

9.5.1 *Concrete Surrounds and Ancorage* – When pipes are encased in concrete either as a protective surround or as an anchorage, membranes, such as felt or polyethylene film, should be placed between the concrete and the PVC pipe.

9.5.2 Where differential movement is likely to occur at the ends of a concrete surround the adjacent pipe-line should comprise one or more short lengths of pipe jointed by means of a double socket fitting incorporating rubber ring sealing.

9.5.3 It should be noted that any side connections into the line except at the point of anchorage, will be subjected to lateral movement and that their supports should be placed at sufficient distance away from the branch connection or bend to ensure that excessive lateral bending does not occur.

9.6 Notch Effect

A rigid PVC pipe is highly sensitive to the presence of notch, that is the existence of a very small notch affects the impact resistance considerably. This largely depends upon the shape of the notch. The impact value should be considered only as 1/3 to 1/10 of the value without notch, when the notches are present. The sharp edged 'V' notches are dangerous but curved 'U' shaped notches are tolerable. Therefore, threading in the pipe should be discouraged wherever possible. Only injection moulded threaded (with curved ends) fittings should be used.

CHAPTER 6 TESTING AND DISINFECTION

1 TESTING OF CAST IRON PIPE-LINE

1.1 Types of Tests

After a new pipe has been laid, jointed and backfilled in accordance with Chapter 5 (or any valved section thereof) it shall be subjected to the following two tests:

a) Pressure test at a pressure as specified in **1.2** and

b) Leakage test at a pressure to be specified by the authority for a duration of two hours.

.2 Procedure for Pressure Test

.2.1 *Pressure Test*

The field test pressure to be imposed should be not less than the greatest of the following:

a) One and a half times the maximum sustained operating pressure,

b) One and a half times of the maximum pipe-line static pressure, and

c) Sum of the maximum static pressure and surge pressure subject to the works test pressure.

Where the field test pressure is less than two thirds the works test pressure, the period of test should be increased to at least 24 hours. The test pressure shall be gradually raised at the rate of nearly 0.1 MPa (1kgf/cm^2) per minute.

If the pressure measurements are not made at the lowest point of the section, an allowance should be made for the static head between the lowest point, and the point of measurement to ensure, that the maximum pressure is not exceeded at the lowest point. If a drop in pressure occurs, the quantity of water added in order to re-establish the test pressure should be carefully measured. This should not exceed 0.1 litre per mm of pipe dia per km of pipe-line per day for each 30 metres head of pressure applied.

1.2.2 *Pressurization*

Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of lowest point of the linear section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the authority.

1.2.3 *Examination under Pressure*

All exposed pipes, fittings, valves hydrants and joints should be carefully examined during the open-trench test. When the joints are made with lead, all such joints showing visible leaks shall be recaulked until tight. When the joints are made with cement and show seepage or slight leakage, such joints shall be cut out and replaced as directed by the authority. Any cracked or defective pipes, fittings, valves or hydrants discovered in consequence of this pressure test shall be removed and replaced by sound material and the test shall be repeated until satisfactory to the authority.

1.3 Procedure for Leakage Test

1.3.1 A leakage test shall be conducted concurrently with the pressure test. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valved section thereof within 0.035 MPa (0.35 kgf/cm^2), of the specified leakage test pressure after the air in the pipe-line has been expelled and the pipe has been filled with water.

1.3.2 No pipe installation shall be accepted until the leakage is less than the number of cm^3/h as determined by the formula:

$$q_L = \frac{ND\sqrt{p}}{10}$$

where

q_L = the allowable leakage in cm^3/h,

N = number of joints in the length of the pipe-line,

D = diameter in mm, and

p = the average test pressure during the leakage test in MPa.

1.3.3 *Varation from Permissible Leaking*

Where any test of pipe laid indicates leakage greater than that specified in **1.3.2** the defective joints shall be repaired until the leakage is within the specified allowances.

1.4 Prerequisite of Test

1.4.1 Where any section of a main is provided with concrete thrust blocks or anchorages in accordance with **3.8** of Chapter 5 the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the test shall not be made until at least two days have elapsed.

1.4.2 *Back-Filling*

Before testing, the trench can be partially back-filled, if required by site condition, except at the joints in accordance with Chapter 5. Such back-filling shall be done after obtaining the permission from the authority concerned.

1.4.3 *Time for Testing of Lead Jointed Pipe*

If the requirements of **1.4.1** have been complied with, a lead jointed pipe may be subjected to hydrostatic pressure, inspected and test for leakage at any convenient time after the trench has been back-filled in accordance with **1.4.2**.

1.4.4 *Time for Testing of Cement Jointed Pipe*

After the requirements of **1.4.1** have been complied with and the trench back-filled in accordance with **1.4.2** the main shall be filled with water in the manner specified in **3.9.5.3** of Chapter 5 and **1.2.1** and shall not be subjected to hydrostatic pressure; inspected and tested for leakage till at least 36 hours have elapsed thereafter. The pipe shall remain full of water until all tests have been made.

1.4.5 In case where there are no valves, or valved sections are too long, the testing may be permitted to be carried out in suitable segments with the permission of the authority.

2 TESTING OF DUCTILE IRON PIPE-LINE

2.1 After a new pipe-line is laid and jointed, testing shall be done for:

a) mechanical soundness and leak tightness of pipes and fittings;

b) leak tightness of joints; and

c) soundness of any construction work, in particular that of the anchorages.

2.2 Hydrostatic Testing

The completed pipe-line may be tested either in one length or in sections; the length of section depending upon:

a) availability of sufficient water,

b) number of joints to be inspected, and

c) difference in elevation between one part of the pipe-line and another.

Where the joints are left uncovered until after testing, sufficient material should be back-filled over the centre of each pipe to prevent movement under the test pressure.

It is prudent to begin testing in comparatively short length of test section. Progressively as experience is gained, lengths of about 1.5 km or more, are tested in one section, subject to consideration of length of trench which can be left open in particular circumstances.

Each section should be properly sealed-off, preferably with special stop ends secured by adequate temporary anchors. The thrust on the stop ends should be calculated and the anchors designed to resist it. All permanent anchors (*see* **4.8** of Chapter 5) should be in position and, if of concrete, should have developed adequate strength before testing begins. The section under test should be filled with water, taking care that all the air is displaced either through vents at the high points or by using a pig or a sphere.

2.3 The test pressure to be applied should be not less than any of the following:

a) The maximum sustained operating pressure,

b) The maximum static pressure plus 5 MPa (50 kgf/cm^2), and

c) The sum of the maximum sustained operating pressure (or the maximum static pressure) and the maximum calculated surge pressure.

After filling, the pipe-line should be pressurized to the specified operating pressure and left for a period of time to achieve stable conditions.

The length of this period of time depends on many factors such as slight movement of the pipe-line under pressure whether air is trapped in the pipe-line or whether the pipe-line has a concrete lining which absorbs water.

The pipe-line is then pressurized up to the full test pressure and the section under test completely closed off. The test pressure should be maintained for a period of not less than 10 minutes to reveal any defects in the pipes, joints or anchorages.

The test pressure should be measured at the lowest point of the section under test or alternatively, an allowance should be made for the static head between the lowest point and the point of measurement, to ensure that the required test pressure is not exceeded at the lowest point.

2.4 In case of extreme temperature conditions, there may be a tendency of hydraulic pressure building up inside the pipe-line because of expansion of water during the day time. This should normally not be of any major concern as the joints and the pipes are manufactured to resist a much higher pressure. However, sufficient care should be taken to prevent floating or bulging of the pipe-line because of building up of such high pressure during the temperature rise.

2.4.1 If the test is not satisfactory, the fault should be found and rectified. Where there is difficulty in locating a fault, the section under test should be subdivided and each part tested separately.

Methods employed for finding leaks include:

a) Visual inspection of each joint, if not covered by the backfill;

b) Use of a bar probe to detect signs of water in the vicinity of joints, if back-filled;

c) Aural inspection using a stethoscope or listening stick in contact with the pipeline;

d) Use of electronic listening device which detects and amplifies the sound or vibrations due to escaping of water, actual contact between the probe and the pipe is not essential;

e) Injection of a dye into the test water-particularly suitable in water-logged ground; and

f) Introduction of nitrous oxide in solution into the test water and using an infra-red gas concentration indicator to detect the presence of any nitrous oxide that has escaped through the leak.

2.5 After all sections have been joined together on completion of section testing, a test on the complete pipe-line should be carried out. This test should be carried out at a pessure not less than the maximum sustained operating pressure or the maximum static pressure of the pipe-line and, during the test, inspection made of all works which have not been subjected to section tests. During the test, the pressure at the lowest point in the pipe-line should not exceed the maximum given in Table 1.

Table 1 Maximum Field Hydrostatic Test Pressure for Ductile Iron Pipe-Lines with Flexible Joints

(*Clause* 2.5)

Nominal Bore mm	Maximum Field Hydrostatic Test Pressure MPa (kgf/cm²)
Up to 300	4.5 (45)
350 to 600	3.0 (30)
700 to 1 200	2.1 (21)

NOTES

1 The above pressures are 0.5 MPa (5.0 kgf/cm²) higher than the pressure ratings for ductile iron pipes and fittings with flexible joints. It is not considered necessary to field test ductile iron pipe-lines to 1½ times the design operating pressure as is often the practice with cast iron pipe-lines.

2 The field test pressures is applied to ductile iron pipe-lines only when the pipe-line and its fittings are properly anchored.

2.6 It is important to ensure that proper arrangements are made for the disposal of water from the pipe-line after completion of hydrostatic testing and that all consents which may be required from authorities have been obtained. In some cases, for example, for heavily chlorinated water, some treatment may be necessary before final disposal.

3 TESTING OF STEEL PIPE-LINE

3.1 General

Before putting it into commission, the welded pipeline shall be tested both for its strength and leakage.

3.2 Procedure for Test

Each valved section of the pipe shall be slowly filled with clean water and all air shall be expelled from the pipe-line through hydrants, air valves and blow-offs fixed on the pipe-line. Before starting the pressure test, the expansion joints should be tightened.

3.2.1 *Pressure Test*

The field test pressure to be imposed should be not less than the greatest of the following:

a) $1\frac{1}{2}$ times the maximum sustained operating pressure,

b) $1\frac{1}{2}$ times the maximum pipe-line static pressure, and

c) Sum of the maximum static pressure and surge pressure subject to the test pressure.

Where the field test pressure is less than two thirds the test pressure, the period of test should be at least 24 hours. The test pressure shall be gradually raised at the rate of nearly 0.1 MPa per minute (1 kgf/cm^2 per minute).

If the test pressure measurements are not made at the lowest point of the section, an allowance should be made for the static head between the lowest point and the point of measurement to ensure that the maximum pressure is not exceeded at the lowest point. If a drop in pressure occurs, the quantity of water added in order to re-establish the test pressure should be carefully measured. This should not exceed 0.1 litre per mm of pipe dia per km of pipe-line per day for each 30 m head of pressure applied.

Where the pipe-line is tested in sections, two or more welded joints at each gap may not get tested under pressure. Special care should be taken in making these welds and these joints should be kept under observation during the commissioning of the system.

3.2.2 *Pressurization*

Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of lowest joint of the linear section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the authority.

3.2.3 *Examination Under Pressure*

Under the test pressure no leak or sweating shall be visble at all section of pipes, fittings, valves, hydrants and welded joints. Any defective pipes, fittings, valves or hydrants discovered in consequence of this pressure test shall be removed and replaced by sound material and the test shall be repeated until satisfactory to the authority.

4 TESTING OF CONCRETE PIPE-LINE

4.1 General

All pipe-lines should be tested before being brought into service. The test should be a hydrostatic test performed by filling the pipe-line with water and raising the pressure to the selected test pressure and maintaining this for a sufficient period to allow for absorption of water by the pipe material. A graph of quantity of water added to maintain the test pressure against time will show when absorption of water is substantially completed. In the case of large diameter low pressure pipes consideration may be given to internal testing of joints only.

4.2 Site Test Pressure

The site test pressure to be imposed should have already been determined when placing orders for pipes and fittings. In general, this pressure should not be less than the maximum pipe-line operating pressure plus the calculated surge pressure allowance, but in no case, should it exceed the works hydrostatic proof test pressure. If pressure measurements are not made at the lowest point of the section under test, an allowance should be made for the static head between the lowest point and the point of measurement to ensure that the maximum pressure is not exceeded at the lowest point.

4.3 Test Procedure

At the commencement of a pipe laying project, it is prudent to test comparatively short section in order to establish the test procedure and gain experience; thereafter, the test may be applied to longer lengths.

Each section should be properly sealed off, preferably with special stop ends secured by adequate anchors. The thrust on the stop ends should be calculated on the full socket internal diameter and the anchors designed to resist it. It may often be economical to provide a concrete anchor block of couple of pipes laid and earth tamped around which has subsequently to be demolished rather than risk movement of the stop ends during testing. Hydraulic jacks may be inserted between the temporary anchors and stop ends in order to take up any horizontal movement of the temporary anchor. All permanent anchors should be in position and, if of concrete, should have developed adequate strength before testing begins. The section under test should be filled with water, taking care that all air is displaced either through vents at the high points, or by using a swab.

After filling, the pipe-line should be left under operating pressure for a period in order to achieve conditions as stable as possible for testing. The length of this period will depend upon many factors such as initial permeability, absorption, movement of the pipeline under pressure and the quantity of air trapped. More water should be pumped in from a calibrated container until the required test pressure is reached. The test pressure should be maintained throughout the test by means of continuous pumping, using a pressure relief valve. The excess water coming from the relief valve from the container should be returned to the calibrated container. The rate of loss of water from the container should be determined at regular intervals; the standard of acceptance should be clearly specified and the test should be continued until this is achieved. The generally accepted standard for non-absorbent pipe-lines such as steel and iron is 0.1 litre per millimetre of pipe diameter per kilometre of pipe-line per day for each 30 metre head of pressure applied. Concrete is an absorbent and permeable material, the factors which govern the absorption and permeability are very complex and they cannot at the present time be subject to accurate analysis. It is known, however, the following factors play an important part:

a) The density of the concrete,

b) The amount of surplus (non-combined) water present in the concrete at the commencement of the test,

c) The amount and quality of the cement matrix (water-cement ratio and cement content of mix),

d) The thickness of the concrete unit under test,

e) The pressure applied, and

f) The duration of the test.

Laboratory permeability tests are usually conducted under very low heads (about 0.1 atmosphere) which is in the order of 1 percent of the operating pressure of many trunk water mains. For low head laboratory permeability tests, the permeability coefficient may be in the range of 1×10^{-8} to 1×10^{-10} cm^3/s per cm^2 (area of concrete under test) per cm (thickness of concrete section under test). Air voids in well compacted mature concrete may occupy 1 percent of the volume of the concrete. As an example of the effect of items (a) and (b) only, when concrete has been artificially dried and then placed in water without any applied pressure, the accepted absorption of good quality concrete should not exceed 6.5 per cent by mass of the concrete in 24 hours. For concrete pressure pipe, 900 mm diameter, under a test pressure of 100 m head, a figure of 6 percent for artificially dried concrete may amount to about 48 000 l/km in 24 hours. For concrete pipe-lines, the standard of acceptability for non-absorbent pipe-lines quoted above can be achieved only when absorption is complete. In the case of concrete pipes, the attainment of this standard may be costly and time consuming process with no equivalent advantage obtained in the from of a higher standard of completed pipe-line and it may be preferable to specify for the rate of loss of water from the container a figure more appropriate to the absorption characteristics of concrete and thus larger than the figure quoted for non-absorbent pipe-lines. A value of 3 litres per mm diameter per km per 24 hours per 30 m head is recommended.

4.4 Leak Detection

If the test is not satisfactory, the fault should be found and rectified. Where there is difficulty in locating a fault, the section under test should be subdivided and each part tested separately.

Method employed for finding leakage include:

a) visual inspection of each joint if not covered by the backfill;

b) use of a bar probe to detect signs of water in the vicinity of joints if backfilled;

c) aural inspection using a stethoscope or listening stick in contact with the pipe-line;

d) use of an electronic listening device which detects and amplifies the sound of escaping fluid (actual contact between the probe and the pipe is not essential);

e) injection of a dye into test water (paticularly suitable in waterlogged ground but subject to approval by the appropriate authority); and

f) introduction of nitrous oxide in solution into the test water, using an infra-red gas concentration indicator to detect the presence of any nitrous oxide that has escaped through the leakage.

4.5 Final Testing

After all sections have been jointed together on completion of section testing, a test on the complete pipeline should be carried out. This test should be carried out at a pressure not less than the working pressure of the pipe-line, care being taken to ensure that the pressure at the lowest point in the pipeline does not exceed the maximum. During the test, an inspection should be made of all works which have not been subjected to sectional tests.

5 TESTING OF ASBESTOS CEMENT PIPE LINES

5.1 It is recommended to test the portions of the line by subjecting to pressure test as in **5.2** as the laying progresses before the entire line is checked. In this way any error of workmanship will be found immediately and can be corrected at a minimum cost.

5.1.1 Usually the length of the section to be tested shall not exceed 500 m.

5.2 The pipes shall be tested as specified in IS 5913 : 1970 in the factory and hence the purpose of held testing is to check the quality of workmanship and also to check whether the pipes have been damaged in transit. As such, the test pressure shall be kept as 1.5 times the actual operating pressure, unless a higher test pressure is specified. However, it may be noted that the test pressure during the field test shall not exceed the values given in Table 2.

Table 2 Test Pressure for Asbestos Pipes
(*Clause* 5.2)

Class of Pipe (1)	Maximum Field Test Pressure Mpa (kgf/cm²) (2)
5	0.375 (3.75)
10	0.75 (7.50)
15	1.125 (11.25)
20	1.50 (15.00)
25	1.875 (18.75)

5.3 Prior to testing enough back fill shall be placed over the pipe-line to resist upward thrust. All thrust blocks forming part of the finished line shall have been sufficiently cured and no temporary bracing shall be used.

5.4 The open end of the section can be sealed temporarily with an end cap having an outlet which can serve as an air relief vent or for filling the line, as may be required.

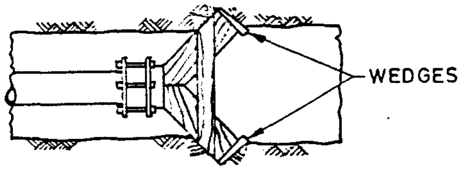
5.5 The blind face of the end cap shall be properly braced during testing by screw jacks and wooden planks or steel plate (*see* Fig. 1).

5.6 The section of the line to be tested shall be filled with water manually or by a low pressure pump. Air shall be vented from all high spots in the pipe-line before making the pressure strength test because entrapped air gets compressed and causes difficulty in raising the required pressure for the pressure strength test.

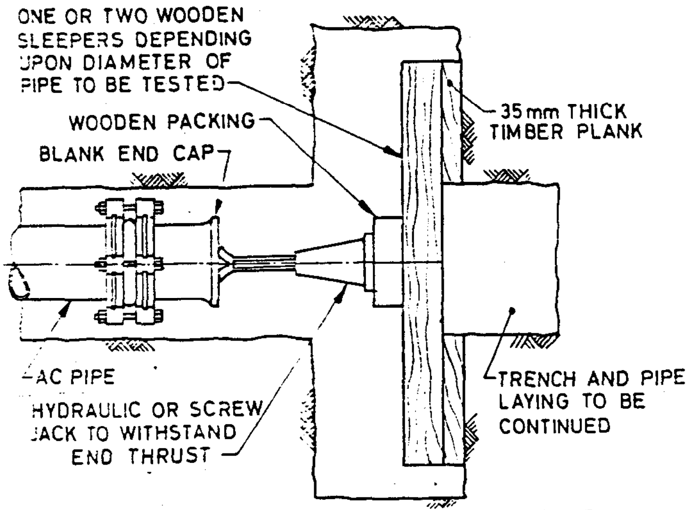
5.7 Asbestos cement pipes always absorb a certain amount of water. Therefore, after the line is filled, it should be allowed to stand for 24 h, before pressure testing and the line shall be again filled.

5.8 The test pressure shall be gradually raised at the rate of approximately one 0.1 Mpa/min (1 kgf/cm²/min).

5.9 The duration of the test period if not specified shall be sufficient to make a careful check on the pipe-line section.



END CLOSURE FOR PIPES UP TO 125 mm NOMINAL DIA


ONE OR TWO WOODEN SLEEPERS DEPENDING UPON DIAMETER OF PIPE TO BE TESTED
WOODEN PACKING
BLANK END CAP
35 mm THICK TIMBER PLANK
AC PIPE
HYDRAULIC OR SCREW JACK TO WITHSTAND END THRUST
TRENCH AND PIPE LAYING TO BE CONTINUED

END CLOSURE FOR PIPES 125 mm AND OVER NOMINAL DIA

FIG. 1 TYPICAL DETAIL OF SHORING AT THE PIPE END FOR TESTING

5.9.1 After the test has been completed, the trench shall be filled as described in **2.4** of Chapter 5.

6 TESTING OF POLYETHYLENE AND UPVC PIPE LINES

6.1 All pipe works, fittings and appliances shall be inspected and tested hydraulically after the completion of installation. Before starting any test the system shall be visually inspected to ensure that the recommendations for the correct installation procedure have been complied with, and that the pipeline together with appliances, valves and fittings are laid in the prescribed manner. Solvent welded pipelines should not be pressure tested until at least 24 hours after the last solvent welded joint has been made.

6.2 All control valves shall be positioned 'open' for the duration of the test and open ends temporarily closed with water-tight fittings. The testing pressure should not be less than one and a half times the rated pressure of the pipe under use.

6.3 Pressure should be applied either by hand pump or power driven pump. Pressure gauges should be correctly positioned and closely observed to ensure that at no time the test pressures are exceeded. The system should be slowly and carefully filled with water, to avoid surge pressure of water hammer. Air vents should be open at all high points so that air may be expelled from the system during filling.

6.4 When the system has been fully charged with water and air displaced from the line, air vents should be closed and the line initially inspected for seepage at joints and the firmness of support under load. Pressure then may be applied until the required test pressure is reached (*see* Note).

NOTE — Thermoplastic pipes expand under pressure to a greater extent than pipes of asbestos cement or cast iron. This expansion is due to low modulus of elasticity of the material and results in initial fall of pressure even though there is no leakage for all the four pressure classification of pipes. The amount of water required to build up a steady test pressure for the plastics pipes is given in Table 3 and Table 4 for polyethylene and PVC pipes respectively. The values are only approximate to give a guideline as variations occur due to temperature fluctuation and variation in test pressure and wall thickness. The time taken to build up approximate steady pressure is 12 hours. Without any additional requirement of make up water, the test pressure should not fall more than 0.02 MPa (0.2 kgf/cm^2) at the end of one hour test duration. This extra quantity of water required is normally termed as make up water.

Table 3 Make Up Water Required While Testing Polyethylene Piping
(*Clause* 6.4)

Nominal Size mm (1)	Litre/100 m Line (2)
25	1.1
32	1.6
40	2.6
50	4.0
65	5.9
80	8.5
100	16.4
125	26.9

Table 4 Make Up Water Required While Testing PVC Piping
(*Clause* 6.4)

Nominal Size (1)	Litre/100 m Line mm (2)
50	2.28
75	4.55
100	6.83
125	10.92
150	14.56
180	18.20
200	22.30

7 FLUSHING AND DISINFECTION OF MAINS BEFORE COMMISSIONING

7.1 The mains intended for potable water supplies should be disinfected before commissioning them for use.

7.1.1 *Distribution System Chlorination of New Mains*

Special care should be taken to ensure disinfection of new mains. Among possible sources of contaimination are sewer drainage contaminated soil in the trench, contamination from workmen or their equipment or both and unavoidable foreign material present in the trench during construction.

7.1.2 Education of crew members as to the need for avoiding contamination of the main during construction is fundamental. Contractors and workmen should be thoroughly familiar with all pertinent state and local requirements governing installation of mains. All sewers water mains and other underground conduits should be located prior to construction and relocated, if necessary, to prevent contamination during construction. Pipe should be strung on high ground. At all times when construction is not actually in progress, watertight plugs should be installed in all pipe openings. Gunny sacks and rags are not adequate. Provision should be made to pump any other water that might collect in the trench. Special care should be taken to avoid contamination of valves, fittings, and pipe interiors, both before and during construction each of them should be inspected and, if necessary, cleaned before installation.

7.1.3 After pressure testing the main, it should be flushed with water of sufficient velocity to remove all dirt and other foreign materials. When this process has been completed, disinfection (using liquid chlorine, or sodium/calcium hypochlorite) should proceed by one of the recommended methods as described in 7.2 and 7.3.

7.2 Continuous Feed

In this method, water from the distribution system or other approved source and the chlorine is fed at constant rate into the new main at a concentration of at least 20 mg/l. A properly adjusted hypochlorite solution injected into the main with a hypochlorinator, or liquid chlorine injected into the main through a solution-feed chlorinator and booster pump may be used. The chlorine residual should be checked at intervals to ensure that the proper level is maintained. Chlorine application should continue until the entire main is filled. All valves, hydrants, etc, along the main should be operated to ensure their proper disinfection. The water should remain in the main for a minimum of 24 hours. Following the 24 hours period no less than 10 mg/l chlorine residual should remain in the main.

7.3 Slug Method

In this method a continuous flow of water is fed with a constant dose of chlorine (as in the previous method) but with rates proportioned to give a chlorine concentration of at least 300 mg/l. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that contacts all interior surfaces of the main for a period of at least 3 hours. As the slug passes tees, crosses, etc, proper valves shall be operated to ensure their disinfection. This method is used principally for large diameter mains where continuous feed is impractical.

7.4 Regardless of the method used, it is necessary to make certain that backflow of the strong chlorine solution into the supplying line does not occur. Following the prescribed contact period, the chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating that throughout the rest of the system. Bacteriological tests as prescribed by the authorities should be taken, and if the results fail to meet minimum standards, the disinfecting procedure should be repeated and the results again tested before placing the main in service.

CHAPTER 7 MAINTENANCE AND REPAIRS OF PIPE-LINES

1 Once pipe laying is completed it is necessary to pay great attention to its maintenance so as to ensure a continuous supply of drinking water of good quality in sufficient quantity.

2 PREVENTIVE MAINTENENCE

2.1 Preventive maintenence of water distribution system pipe-lines assures the twin objectives of preserving the hygienic quality of water in the distribution mains and providing conditions for adequate flow through the pipe-lines. The important aspects of preventive maintenence of water mains are assessment, detection and prevention of wastage of water from pipe-lines and maintaining the carrying capacity of pipe-lines by cleaning of pipe-lines.

2.2 Waste in water supply mains may be caused due to corrosion, fracture, faulty joints, improper ferrule connections, etc. Waste in the service pipes and fittings inside the consumers premises are caused due to faulty joints, corrosion, faulty washers on glands in valves and taps.

2.3 A systematic leakage survey and detection, followed by prompt corrective action is of importance in bringing about a reduction in the wastage. The frequency and extent of survey depends on the cost and net benefit accruing therefrom.

2.4 Assessment of Waste

2.4.1 In case of 24 hours supply, it is possible to assess total wastage occurring in pipe-line when the consumption is at the minimum. The difference between minimum flow in the system and accountable flow at that time divided by average daily flow multiplied by 100 gives the percentage of waste in that area.

2.4.2 In intermittent supplies the percentage of wastage is the ratio of flow in the mains (with all stop cocks and taps closed) to the average daily consumption.

2.4.3 Remedial measures are called for if wastage is above 10 percent.

2.5 Leakage Detection

Leakage detection survey is confined only to the areas with heavy leakages as arrived at by the waste assessment survey. This survey consists of:

a) Finding leaks in the pipes by visual inspection of surface, and
b) Traversing the subzone in the night by sounding rod, or stethoscope or electronic leak detector for pinpointing leaks in pipes.

2.6 Instruments Used in Pipe-line Maintenence

For flow and pressure measurements, location of pipeline and detection of under ground leaks through pipes the following instruments are used and any water supply undertaking should possess some of the simple and few of the sophisticated instruments.

2.6.1 *Pitometer Assembly*

Used for measurement of single point velocity at the centre line of pipe.

2.6.2 *Pressure Gauge (with Recorder)*

Spring type of pressure gauge used to measure pressure at various points on the pipe-line. Recorder permits the continuous record of pressures with time.

2.6.3 *Integrating Type Water Meter*

Normal integrating turbine type meter measures the flow between the two hydrants connected by pressure hose serving as bypass before feeding into zone or subzone (isolated section of system). Normally 25 mm to 80 mm diameter are used.

2.6.4 *Mobile Waste Water Flowmeter*

The integrating rate of flow meter that can be mounted on a trailer is used for measuring the waste flow in a subzone (isolated section of system). The rate of flow with reference to time is recorded on a down chart.

2.6.5 *Hydrants and Hose Pipe*

These are required for bypassing the feed pipe to the zone through the integrating or waste meter.

2.6.6 *Electronic Valve Box Locator*

This is to locate buried metals under ground up to a depth of about 0.25 to 0.5 m below the surface.

2.6.7 *Electronic Pipe-line Locator*

By means of electro magnetic induction and wireless signals, the existence and exact alignment of underground metallic pipe-line can be found.

2.6.8 *Sounding Rod*

It is a 1.2 m long, 12 mm diameter hollow mild steel rod or flat pointed at one end and fixed with cup shaped brasscap of 50 mm diameter at the other. Bamboo canes can also be used. The rod is traversed along the centre line of pipe and the noises due to water leakage are picked up by human ear thus locating the possible leaks.

2.6.9 *Electronic Leak Detector*

It consist of a pick up, amplifier head phones. The sound vibrations created by water escaping through leaks in pipes are picked up and magnified by the magnetic pick up and converted to electrical impulses. These are sensitive and can pin point the position of leaks.

2.7 Corrective Action

After location of leaks corrective steps in the pipes and valves are to be undertaken and flow test to be done again to determine the extent and efficiency of repairs. If the result is not satisfactory, the entire exercise has to be repeated.

2.8 Cleaning of Pipes

2.8.1 The water carrying capacity of pipe-line gets reduced due to growth of slime or incrustation. Hence it is necessary to clean the pipes periodically to maintain the carrying capacity. Flushing and swabbing are simple and common methods adopted in cleaning of pipes.

2.8.2 *Flushing*

Water at high velocity is allowed to flow in the pipe and finally escape through a scour valve or hydrant. The minimum velocity to be induced varies from 90 to 120 cm/s and it is to be ensured that the flow is in one direction and the dirty water does not enter the cleaned section. Flushing can only remove loose deposites of small size and not the slimy layers and hard incrustations. Flushing disentangles microscopic biological type growth also, which if left unattended are likely to grow further and create problems. The period of flushing is determined by the quantity of out going water in hydrants or valves. Usually this amounts to flushing out a volume of water equal to twice the capacity of the pipe length under consideration. About 100 to 300 m length of pipe can be flushed in one operation.

2.9 Swabbing

The swab used is made of polyurethene foam of cylindrical shape 30 to 60 cm long with varying diameters. The swab is soft, flexible, highly compressible and can retain the original shape when released from compression. Two varieties of swabs are available. One is soft and other is relatively hard.

2.9.1 The swab is pushed into the pipe by the momentum of the flowing water. As the swab moves it sweeps out the loose and slimy layer adhering to the inner walls of pipe-line and the deposit are carried away by the flowing water. Swabbing is not suitable for cleaning of hard deposits in pipe-line.

2.9.2 Swabs are slightly larger in diameter than the pipe to be cleaned. In certain cases with highly encrusted pipes, swabs of diameter equal to that of pipes to be cleaned are used initially. For pipes of diameter 75 to 100 mm, the swab diameter is usually 25 mm larger while for larger diameter pipes it is 50 to 75 mm larger in size.

2.9.3 The length of mains to be cleaned is isolated. The swabs dipped in bleaching powder solution is inserted into mains through a hydrant or valve body and water is allowed into that section keeping the exit hydrant or valve open. The movement of swab depends on the rate of flow or velocity of flush in the pipe which usually should not be less than 30 cm/s.

3 GENERAL MAINTENANCE

3.1 Sufficient stock of spare pipes and specials should be maintained for replacement of damaged ones.

3.2 Regular leak detection survey should be undertaken and leaking joints should be repaired and broken (burst) pipes should be replaced.

3.3 A detailed record of break-downs and leaks observed, and the repairs undertaken should be maintained sectionwise so that more vulnerable length could be identified and special measures to repair or replace them could be undertaken.

3.4 A regular schedule of inspection and attendance to all valves including air and scour valves should be drawn up and it should be followed scrupulously. Special attention should be given to air valves.

3.5 Special Care for Steel Pipes Laid Above the Ground

3.5.1 Pipes should be painted periodically to prevent corrosion.

3.5.2 Appurtenances such as sluice valves, air valves; rollers, expansion joints should be checked and cleaned periodically. The cleaning and lubrication of rollers should be done twice a year that is before and after the monsoon.

3.5.3 The catch drains provided for the portion of water mains laid in cutting should be cleaned before onset of monsoon so that no water accumulates in cutting portion.

CHAPTER 8 PIPE-LINE CORROSION AND INCRUSTATION

1 Corrosion is destructive attack on a metal by chemical or electro-chemical reaction by the environment. Deterioration by physical causes is not called corrosion but is described as erosion, galling or wear. Rusting applies to corrosion of iron or iron base alloys with the formation of corrosive products consisting largly of hydro ferric oxides. Non-ferrous metals, therefore, corrode but do not rust. Various types of corrosion that would attack pipe-line are given below.

1.1 General Corrosion

General corrosion can take two forms, even and uneven. The former gives readily predictable design life but the latter would tend to produce unexpected early failure.

1.2 Localised Corrosion

It involves certain areas of the metal surface corroding at higher rates than others due to "heterogeneties" in the metal, the environment or in the geometry of the structure. Crevice corrosion, bimetallic corrosion, intergranular corrosion, weld decay are all manifestation of localised corrosion.

1.3 Crevice Corrosion

It is related to differential aeration. Narrow crevices may be formed during the fabrication or construction of a pipes, such as at flanged or threaded joints and some welds and also if the metal is in contact with nonmetallic solids such as plastics or glass, or if there are sand, dust or permeable corrosion products inside the pipe. The essential features of crevice corrosion are availability of cathodic areas where a reactant, usually dissolved oxygen, can gain ready access and a crevice into which diffusion is dificult. Porous gaskets on flanged joints allow penetration of water and form very effective condition for crevice corrosion. Chloride ions also stimulate crevice corrosion. The mechanism is not simply differential aeration, but also the build up of acid in the crevice due to migration of anions from bulk solution to balance the production of metal ions in the crevice after deoxygenation of the crevice solution.

1.4 Bimetallic Corrosion

It can occur where two pipes of different metals are joined (for example a brass coupling used in a steel pipes). Certain metals in combination will generate an electro motive force (emf) with one corroding preferentially. The greatest problem occurs when the corroding metal occupies a small area of surface in conjuction with a large cathode area. This situation can result in rapid pitting of pipe.

1.5 Pitting

Pitting is highly localised attack at specific areas resulting in the formation of small pits which may eventually lead to perforations. Many of the forms of corrosion are referred to as pitting but strictly speaking pitting refers to corrosive attack on passive metals and alloys like stainless steel and aluminium often in the presence of specific ions, such as chloride ions.

1.6 Underground Corrosion

Underground corrosion is probably the most difficult to access and control effectively. Factors that control corrosivity of soil are amount of (a) porosity (aeration), (b) electrical conductivity, (c) dissolved salts, (d) moisture, and (e) acidity or alkalinity present in the soil.

1.7 Microbiological Corrosion

It is associated with clayee soils where a particular type of bacteria, depolarises the cathodic reaction by reducing sulphate ions to sulphide ions utilising small amounts of hydrogen liberated at cathode and promoting rapid corrosion. The sulphide formed is probably the major cause of corrosion.

1.8 Stray Current Corrosion

It poses a serious problem in areas where there is a extraneous electrical current. These electric currents prefer to pass along the lower resistance path provided by a continuous metal pipe-line. The point where the stray current enters becomes a cathode and the point where it leaves an anode and this point gets corroded. If the pipe is coated with an insulating coating, the problem can be made more serious due to rapid perforation of pipe at pinholes in the coating.

2 CORROSION PREVENTION

The following are the methods used for combating corrosion:

a) Selection of proper material

b) Chemical methods

c) Organic coatings

d) Cathodic protection, and

e) Design.

2.1 Selection of Material

After studying the environmental conditions where the pipes are to be used, proper pipe material shall be selected to suit the conditions. The properties of various materials are given in Chapter 2.

2.2 Chemical Methods

Soil rich in organic acids can be made less corrosive by surrounding the pipe with limestone chips. Chalk can be used in soil formation liable to microbiological corrosion. Cement lining for iron water pipes behave in a fashion which puts them into this category, by passivating its surface. Mild steel pipes may also be coated with zinc.

2.3 Organic Coatings

Organic coatings include paints; coaltar applied as a solution, flood coating or wrapping; bitumen applied as coaltar; bitumen tape; tape based on polyethylene with elastomeric based adhesive.

The coatings shall be suitable for the eventual environment of the pipes. For example, paint coatings selected for protection in the open, could fail within months underground where greater water resistance and resistance to aggressive salts and mechanical damage is required. Another important requirement of an organic coating is adhesion to the metal it is protecting.

2.4 Cathodic Protection

Cathodic protection is usually employed as a second line of defence for burried pipe-line. Cathodic protection is either by sacrifical anode or impressed current using an external d.c. source, the choice depending on cost and operating conditions.

2.5 Design

Design of a pipe-line goes a long way towards prevention of corrosion. Factors include correct material selection, avoidance of irregular profiles, etc. Consideration may also be given to the ease of application of protection system and of maintenance.

2.6 For further, more exhaustive study on-the subject of corrosion, see IS 8062 (Parts 1 and 2) : 1976 and IS 10221 : 1982.

3 INCRUSTATION

Deposition of mineral matter on the inner walls of pipe-line is called incrustation. This may occur regardless of pipe material.

Water quality has much to do with the occurrence of incrustation. The kinds and amount of dissolved minerals and gases in natural waters determine their tendency to deposit some of the mineral matter as incrustation.

Incrustation is often a hard, brittle, cement like deposit but sometimes it may be soft and pasty. Generally precipitation of minerals like carbonates of calcium or magnesium causes incrustation.

Incrustation reduces the water carrying capacity of pipe-line. Hence, periodic cleaning of pipes, using swabs should be undertaken.

ANNEX A

LIST OF REFERRED AND OTHER RELEVANT INDIAN STANDARDS

A-1 STEEL PIPES AND FITTINGS

IS 1239	Mild steel tubes, tubulars and other wrought steel fittings
Part 1 : 1990	Mild steel tubes (*fifth revision*)
Part 2 : 1991	Mild steel tubulars and other wrought steel pipe fittings (*third revision*)
IS 1894 : 1972	Method of tensile testing of steel tubes (*third revision*)
IS 1978 : 1982	Line pipe (*second revision*)
IS 3589 : 1991	Seamless and electrically welded steel pipes for water, gas and sewage (168.3 to 2 032 mm outside dia) (*first revision*)
IS 4711 : 1974	Methods for sampling of steel pipes, tubes and fittings (*first revision*)
IS 4736 : 1986	Hot dip zinc coatings on mild steel tubes (*first revision*)
IS 5504 : 1969	Spiral welded pipes
IS 5822 : 1986	Code of practice for laying of welded steel pipes for water supply (*first revision*)
IS 6392 : 1971	Steel pipe flanges
IS 6631 : 1972	Steel pipes for hydraulic purposes
IS 8062	Code of practice for cathodic protection of steel structures
Part 1 : 1976	General principle
Part 2 : 1976	Underground pipe-lines
IS 10221 : 1982	Code of practice for coating and wrapping of underground mild steel pipe-lines
IS 11722 : 1986	Thin walled flexible quick coupling pipes

A-2 CAST & DUCTILE IRON PIPES AND FITTINGS

IS 1536 : 1989	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage (*second revision*)
IS 1537 : 1976	Vertically cast iron pressure pipes for water, gas and sewage (*first revision*)
IS 1538	Cast iron fittings for pressure pipes for water, gas and sewage (*second revision*)
Part 1 : 1976	General requirements
Part 2 : 1976	Specific requirements for sockets and spigots of pipes
Part 3 : 1976	Specific requirements for sockets of fittings
Part 4 : 1976	Specific requirements for flanges of pipes and fittings
Part 5 : 1976	Specific requirements for raised flanges
Part 6 : 1976	Specific requirements for standard flanges drilling of flanged pipes and fittings
Part 7 : 1976	Specific requirements for flanged sockets
Part 8 : 1976	Specific requirements for flanged spigots
Part 9 : 1976	Specific requirements for collars
Part 10 : 1976	Specific requirements for double socket bends
Part 11 : 1976	Specific requirements for tees, all sockets
Part 12 : 1976	Specific requirements for double socket tee with flanged branch
Part 13 : 1976	Specific requirements for crosses, all sockets
Part 14 : 1984	Specific requirements for double socket tapers
Part 15 : 1976	Specific requirements for caps
Part 16 : 1976	Specific requirements for plugs
Part 17 : 1976	Specific requirements for bell mouth pieces
Part 18 : 1976	Specific requirements for double flanged bends
Part 19 : 1976	Specific requirements for all flanged tees
Part 20 : 1976	Specific requirements for all flanged crosses
Part 21 : 1976	Specific requirements for double flanged tapers
Part 22 : 1976	Specific requirements for split puddle or body flanges
Part 23 : 1976	Specific requirements for blank flanges
Part 24 : 1982	Specific requirements for all flanged radial tees

IS 1879 : 1988	Malleable cast iron pipe fittings (*second revision*)
IS 3114 : 1985	Code of practice for laying of cast iron pipes (*first revision*)
IS 6163 : 1978	Centrifugally cast (spun) iron low pressure pipes for water, gas and sewage (*first revision*)
IS 7181 : 1986	Horizontally cast iron double flanged pipes for water, gas and sewage (*first revision*)
IS 8329 : 1990	Centrifugally cast (spun) ductile iron pressure pipes for water, gas and sewage (*first revision*)
IS 9523 : 1980	Ductile iron fittings for pressure pipes for water, gas and sewage
IS 11606 : 1986	Methods of sampling of cast iron pipes and fittings
IS 12288 : 1987	Code of practice for use and laying of ductile iron pipes

A-3 PLASTICS PIPES AND FITTINGS

IS 3076 : 1985	Low density polyethylene pipes for potable water supplies (*second revision*)
IS 4984 : 1987	High density polyethylene pipes for potable water supplies, sewage and industrial effluents (*third revision*)
IS 4985 : 1988	Unplasticized PVC pipes for potable water supplies (*second revision*)
IS 7634	Code of practice for plastics pipe work for potable water supplies
Part 1 : 1975	Choice of materials and general recommendations
Part 2 : 1975	Laying and jointing polyethylene (PE) pipes
Part 3 : 1975	Laying and jointing of unplasticized PVC pipes
IS 7834	Specification for injection moulded PVC socket fittings with solvent cement joints for water supplies
Part 1 : 1987	General requirements (*first revision*)
Part 2 : 1987	Specific requirements for 45 degree elbows (*first revision*)
Part 3 : 1987	Specific requirements for 90 degree elbows (*first revision*)
Part 4 : 1987	Specific requirements for 90 degree tees (*first revision*)
Part 5 : 1987	Specific requirements for 45 degree tees (*first revision*)
Part 6 : 1987	Specific requirements for sockets (*first revision*)
Part 7 : 1987	Specific requirements for unions (*first revision*)
Part 8 : 1987	Specific requirements for caps (*first revision*)
IS 8008	Specification for injection moulded HDPE fittings for potable water supplies
Part 1 : 1976	General requirements
Part 2 : 1976	Specific requirements for 90 degree bends
Part 3 : 1976	Specific requirements for 90 degree tees
Part 4 : 1976	Specific requirements for reducers
Part 5 : 1976	Sepcific requirements for ferrule reducers
Part 6 : 1976	Specific requirements for pipe ends
Part 7 : 1976	Specific requirements for sandwich flanges
IS 8360	Fabricated high density polyethylene (HDPE) fittings for potable water supplies
Part 1 : 1977	General requirements
Part 2 : 1977	Specific requirements for 90 degree tees
Part 3 : 1977	Specific requirements for 90 degree bends
IS 10124	Specification for fabricated PVC fittings for potable water supplies
Part 1 : 1988	General requirements (*first revision*)
Part 2 : 1988	Specific requirements for sockets (*first revision*)
Part 3 : 1988	Specific requirements for straight reducers (*first revision*)
Part 4 : 1988	Specific requirements for caps (*first revision*)
Part 5 : 1988	Specific requirements for equal tees (*first revision*)
Part 6 : 1988	Specific requirements for flanged tail piece with metallic flanges (*first revision*)

Part 7 : 1988	Specific requirements for threaded adaptors (*first revision*)
Part 8 : 1988	Specific requirements for 90 degree bends (*first revision*)
Part 9 : 1988	Specific requirements for 60 degree bends (*first revision*)
Part 10 : 1988	Specific requirements for 45 degree bends (*first revision*)
Part 11 : 1988	Specific requirements for 30 degree bends (*first revision*)
Part 12 : 1988	Specific requirements for $22^{1}/_{2}$ degree bends (*first revision*)
Part 13 : 1988	Specific requirements for $11^{1}/_{4}$ degree bends (*first revision*)
IS 12231 : 1987	Specification for UPVC (rigid) pipes for use in suction and delivery lines of agricultural pumps
IS 12235	Methods of test for unplasticized PVC pipes for potable water supplies
Part 1 : 1986	Method for measurement of outside diameter
Part 2 : 1986	Measurement of wall thickness
Part 3 : 1986	Test for opacity
Part 4 : 1986	Determining the deterimental effect on the composition of water
Part 5 : 1986	Reversion test
Part 6 : 1986	Stress relief test
Part 7 : 1986	Test for resistance to sulphuric acid
Part 8 : 1986	Internal hydrostatic pressure test
Part 9 : 1986	Impact strength test
Part 10 : 1986	Method for determination of organotin as tin aqueous solution
Part 11 : 1986	Extractability of cadmium and mercury occurring as impurities
IS 12709 : 1989	Specification of glass fibre reinforced plastics (GRP) pipes for use for water supply and sewerage.

A-4 CONCRETE PIPES AND FITTINGS

IS 458 : 1988	Concrete pipes (with and without reinforcement) (*third revision*)
IS 783 : 1985	Code of practice for laying of concrete pipes (*first revision*)
IS 784 : 1978	Prestressed concrete pipes (including fittings) (*first revision*)
IS 1916 : 1989	Steel cylinder reinforced concrete pipes (*first revision*)
IS 3597 : 1985	Methods of test for concrete pipes (*first revision*)
IS 7322 : 1985	Specials for steel cylinder reinforced concrete pipes (*first revision*)

A-5 ASBESTOS CEMENT PIPES AND FITTINGS

IS 1592 : 1989	Asbestos cement pressure pipes (*third revision*)
IS 5531 : 1988	Cast iron specials for asbestos cement pressure pipes for water, gas and sewage (*second revision*)
IS 5913 : 1989	Methods of test for asbestos cement products (*first revision*)
IS 6530 : 1972	Code of practice for laying of asbestos cement pressure pipes
IS 8794 : 1988	Cast iron detachable joints for use with asbestos cement pressure pipes (*first revision*)
IS 9627 : 1980	Asbestos cement pressure pipes (light duty)
IS 10292 : 1988	Dimensional requirement for rubber sealing rings for cast iron detachable joints in asbestos cement piping (*first revision*)
IS 10299 : 1982	Cast iron saddle pieces for service connection for asbestos cement pressure pipes
IS 11769	Guidelines for safe use of products containing asbestos
Part 1 : 1987	Asbestos cement products

A-6 VALVES AND OTHER ACCESSORIES

IS 778 : 1984	Copper alloy gate, globe and check valves for water works purposes (*fourth revison*)
IS 780 : 1984	Sluice valves for water-works purpose (50 to 300 mm size) (*sixth revision*)
IS 781 : 1984	Cast copper alloy screw down bib taps and stop valves for water services (*third revision*)
IS 1703 : 1989	Copper alloy float valves (horizontal plunger type) for water fittings (*third revision*)

IS 1711 : 1984	Self closing taps for water supply purposes
IS 2685 : 1971	Code of practice for selection, installation and maintenance of sluice valves (*first revision*)
IS 2692 : 1989	Ferrules for water services (*second revision*)
IS 2906 : 1984	Sluice valves for water works purposes (350 to 1 200 mm size) (*third revision*)
IS 3004 : 1979	Plug cocks for water supply purposes (*first revision*)
IS 3042 : 1965	Single faced sluice gates (200 to 1 200 mm size)
IS 3950 : 1979	Surface boxes for sluice valves (*first revision*)
IS 4038 : 1986	Foot valves for water works purposes (*second revision*)
IS 4346 : 1982	Washers for use with fittings for water services (*first revision*)
IS 4854	Glossary of terms for valves and their parts
Part 1 : 1969	Screw-down stop, check and gate valves and their parts
Part 2 : 1969	Plug valves and cocks and their parts
Part 3 : 1984	Butterfly valves
IS 5312	Swing check type reflux (non-return) valves for water works purposes
Part 1 : 1984	Single-door pattern (*first revison*)
Part 2 : 1986	Multi-door pattern
IS 9338 : 1984	Cast iron screw-down stop valves and stop and check valves for water works purposes (*first revision*)
IS 9739 : 1981	Specification for pressure reducing valves for domestic water supply systems
IS 9762 : 1981	Polyethylene floats for ball valves
IS 9763 : 1988	Plastic bib taps and stop valves (rising spindle) for cold water services (*first revison*)
IS 10805 : 1986	Foot-valves, reflux valves or non-return valves and bore valves to be used in suction lines of agricultural pumping systems (*first revison*)
IS 12234 : 1988	Plastic equilibrium float valves for cold water services
IS 13114 : 1991	Forged brass gate, globe and check valves for water works purposes — Specification

A-7 OTHER STANDARDS

IS 210 : 1978	Grey iron castings (*third revision*)
IS 269 : 1989	Specification for 33 grade ordinary portland cement (*fourth revision*)
IS 318 : 1981	Leaded tin bronze ingots and castings (*second revision*)
IS 320 : 1980	High tensile brass rods and sections (other than forging stock) (*second revision*)
IS 408 : 1981	Specification for grease No. 1, graphited (*second revision*)
IS 455 : 1989	Specification for Portland slag cement (*fourth revision*)
IS 456 : 1978	Code of practice for plain and reinforced concrete (*third revision*)
IS 554 : 1985	Dimensions for pipe threads when pressure tight joints are required on threads (*third revision*)
IS 638 : 1979	Specification for sheet rubber jointing and rubber insertion jointing (*second revision*)
IS 782 : 1978	Caulking lead (*third revision*)
IS 814 : 1991	Covered electrodes for manual arc welding of carbon and carbon manganese steel (*fourth revision*)

IS 816 : 1969	Code of practice for use of metal arc welding for general construction in mild steel (*first revision*)
IS 1387 : 1967	General requirements for the supply metallurgical materials (*first revision*)
IS 1489 : 1991	Specification for Portland pozzolana cement (*third revision*)
IS 2065 : 1983	Code of practice for water supply in buildings (*second revision*)
IS 2107 : 1977	Whiteheart malleable iron castings (*first revision*)
IS 2108 : 1977	Blackheart malleable iron castings (*first revision*)
IS 2405 (Part 2) : 1980	Specification for industrial sieves: Part 2 Perforated plates (*first revision*)
IS 2643 (Part 1) : 1975	Dimensions for pipe threads for fastening purposes : Part 1 Basic profile and dimensions
IS 2720 (Part 7) : 1980	Methods of test for soils : Part 7 Determination of water content — dry density relation using light compaction (*second revision*)
IS 2951 (Part 1) : 1965	Recommendation for estimation of flow of liquids in closed conduits : Part 1 Head loss in straight pipes due to frictional resistance
IS 3487 : 1966	Copper strip and foil for manufacture of copper gaskets and copper washers and eyelets
IS 3600 (Part 1) : 1985	Methods of testing fusion welded joints and weld metal in steel : Part 1 Cruciform fillet weld tensile test
IS 3658 (Part 1) : 1981	Code of practice for liquid penetrant flaw detection (*first revision*)
IS 4081 : 1986	Sefety code for blasting and related drilling operations
IS 4260 : 1986	Recommended practice for ultrasonic testing of butt welds in ferritic steels (*second revision*)
IS 4736 : 1986	Hot-dip zinc coatings on mild steel tubes (*first revision*)
IS 4737 : 1982	Chromite for chemical industries (*first revision*)
IS 4759 : 1984	Hot-dip zinc coatings on structural steel and other allied products (*second revision*)
IS 4853 : 1982	Recommended practice for radiographic inspection of fusion welded butt joints in steel pipes (*first revision*)
IS 5330 : 1984	Criteria for design of anchor blocks for penstocks with expansion joints (*first revision*)
IS 5382 : 1985	Rubber sealing rings for gas mains, water mains and sewage (*first revision*)
IS 6837 : 1973	Three wheel type pipe cutter
IS 6843 : 1984	Technical supply conditions for pipe cutters (*first revision*)
IS 6881 : 1973	Link type pipe cutters
IS 8041 : 1990	Specification for rapid hardening Portland cement (*second revision*)
IS 8043 : 1978	Hydrophobic Portland cement (*second revision*)
IS 8112 : 1989	Specification for 43 grade ordinary Portland cement (*first revision*)
IS 9845 : 1986	Method of analysis for the determination of specific and/or overall migration of constituents of plastics material and articles intended to come into contact with foodstuff (*first revision*)
IS 10221 : 1982	Code of practice for coating and wrapping of underground mild steel pipes
IS 10446 : 1983	Glossary of terms relating to water supply and sanitation
IS 10883 : 1986	Single wheel type pipe cutters

IS 11906 : 1986	Recommendations for cement mortar lining for cast-iron, mild steel and ductile-iron pipes and fittings for transportation of water
IS 12820 : 1989	Dimensional requirements for rubber gaskets for mechanical joints and bush joints for use with cast iron pipes for water, gas and sewage